SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM

HESS CORPORATION
FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

NJDEP PI#006148
ISRA Case No. E20130449
EPA ID No. NJD045445483

Prepared for:

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Belmar, New Jersey

Prepared by:

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October 2019

KEY ENVIRONMENTAL INCORPORATED

PROFESSIONAL ENGINEER SIGNATURE PAGE

I certify that I have provided regular and effective supervision to those individuals performing services that directly and materially affect the quality and competence of the engineering work rendered in the document titled, "Soil Remedial Action Design, AOC-1: North Landfarm, Hess Corporation, Former Port Reading Refining Facility, Port Reading, Middlesex County, New Jersey, NJDEP PI#006148, ISRA Case No. E20130449, EPA ID No. NJD045445483" dated October 16, 2019.

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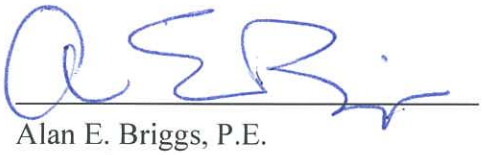

10/16/19

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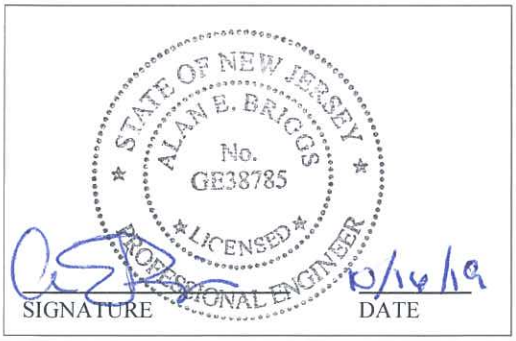

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ACRONYMS / ABBREVIATIONS

AOC	Area of Concern
API	American Petroleum Institute
AST	aboveground storage tank
CEA	Classification Exception Area
CFR	Code of Federal Regulations
cm/sec	centimeters per second
COC	constituent of concern
DSW	Discharge to Surface Water
Facility	Former Port Reading Refining Facility
FEMA	Federal Emergency Management Agency
FCCU	Fluidized Catalytic Cracking Unit
GCL	geosynthetic clay liner
GP	General Permit
Hess	Hess Corporation
HSWA	Hazardous and Solid Waste Amendments
ISRA	Industrial Site Recovery Act
KEY	Key Environmental Inc.
LLDPE	liner low density polyethylene
LOI	Letter of Interpretation
NAD	North American Datum
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJPDES	New Jersey Pollutant Discharge Elimination System
N.J.S.A.	New Jersey Statutes Annotated
NLF	North Landfarm
oz/sy	ounces per square yard
PCB	polychlorinated biphenyl
PCER	Office of Permit Coordination and Environmental Review
RAD	Remedial Action Design
RAO	Remedial Action Objective
RAW/PCMP	Remedial Action Workplan/Post Construction Monitoring Plan
RCRA	Resource Conservation and Recovery Act
SCD	Soil Conservation District
SPPP	Stormwater Pollution Prevention Plan
SVOC	semi-volatile organic compound
TEL	tetraethyl lead
TPH	total petroleum hydrocarbons
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 INTRODUCTION

1.1 BACKGROUND

This Soil Remedial Action Design (RAD) report was prepared by Key Environmental Inc., (KEY) on behalf of Earth Systems, Inc. for the Hess Corporation (Hess) for Area of Concern No. 1 (AOC-1): North Landfarm (NLF or Site), located at the Former Port Reading Refining Facility (Facility) in Port Reading, Middlesex County, New Jersey. NLF is referenced under New Jersey Department of Environmental Protection (NJDEP) Program Interest Number 006148, Industrial Site Recovery Act (ISRA) Case Number E20130449, and the United States Environmental Protection Agency (USEPA) ID No. NJD045445483. This report has been prepared to provide technical information required to meet the design requirements for closure of NLF as identified in the Remedial Action Workplan/Post Construction Monitoring Plan (RAW/PCMP) prepared by Earth Systems and submitted to NJDEP Bureau of Case Management on September 26, 2016. The selected remedy includes the construction of a low permeability cap over NLF to meet the closure performance standards of the Resource Conservation and Recovery Act (RCRA) closure and post-closure requirements, as specified in 40 Code of Federal Regulations (CFR) 265.

1.2 FACILITY DESCRIPTION

The former Hess Facility is an approximate 223-acre irregularly shaped parcel, situated in an industrially developed waterfront area. A vicinity map indicating the location and limits of the Facility is presented on Design Drawing NLF-G-001 included in Appendix C. The Facility formerly processed low sulfur gas oils and residuals as feed to a Fluidized Catalytic Cracking Unit (FCCU) that converted gas oil into gasoline, fuel oil, and other hydrocarbon products (e.g. methane, ethane and liquid petroleum gas). Facility operations were initiated in 1958 with a Crude Topping Unit and underwent various expansions between 1958 and 1970. In 1974, refining operations were suspended and the Facility operated only as a bulk storage and distribution terminal until 1985. In April 1985, following a retrofit, the Facility resumed refining operations. Later the refinery was closed and demolition of the refinery was completed in 2015. Currently the Facility is operated only as a bulk storage and distribution terminal. The refinery utilized on-site land treatment (i.e., landfarming) to effectively treat and dispose of waste.

1.3 LANDFARM HISTORY

The NLF is located near the northeast boundary of the property, within Block 757, Lot 1. The NLF location with respect to the surrounding area and within the Facility is indicated on Design Drawing NLF-G-001. Block identification and limits are provided on Figure 2 of the RAW/PCMP. The NLF was reportedly developed in 1974 by constructing an above-grade earthen dike, 200 feet long and 75 feet wide (approximately 0.33 acres), in the northwest corner of the existing raised earthen dike protected area around Aboveground Storage Tank (AST) 7945. The bottom of the NLF is natural soils with some clay. The existing conditions plan for NLF including

NLF limits, ground surface topography, physical features, and monitoring wells is presented on Design Drawing NLF-C-101.

The NLF reportedly operated from 1975 to 1985, though non-hazardous biomass continued to be applied to the NLF until about 1988. The NLF received RCRA Interim Status in 1980 from NJDEP. The total volume of waste applied to the NLF was estimated at 21 tons, 15 tons of which was classified as hazardous waste. The NLF was identified as a Solid Waste Management Unit (SWMU) during a 1986 RCRA Facility Assessment (RFA) conducted by the United States Environmental Protection Agency (USEPA) under the RCRA Corrective Action Program. In 1988, investigative and remedial requirements for the NLF (and other Facility SWMUs) were incorporated into the Facility's Hazardous and Solid Waste Amendment (HSWA) Permit No. NJD045445483. The USEPA Bureau of Federal Case Management (BFCM) assumed oversight of the NLF in 1995, in addition to other applicable areas of concern.

NLF has ground surface elevations ranging from approximately 9 to 11 feet North American Vertical Datum of 1988 (NAVD88) and is completely surrounded by dike walls. The dike walls have ground surface elevations ranging from approximately 8 to 16.5 feet NAVD88 which prevent surface water from running onto the landfarm. Stormwater outside the boundaries of the landfarm either percolates into the ground or sheet flows to the existing northern drainage ditch, an unnamed tributary to the Arthur Kill.

Seven permitted monitoring wells, designated LN-1 through LN-7 were installed along the western and northern perimeter of the NLF. These monitoring wells were sampled on a quarterly basis in accordance with the NJPDES permit, including analysis for general chemistry, volatile organic compounds (VOCs), metals, and pesticides. Quarterly groundwater monitoring will continue at NLF until closure is completed. The results of the quarterly sampling were reported to the NJDEP on a semiannual basis, with the latest report dated July 2019. Post closure, the groundwater will be monitored for the duration that the Classification Exception Area (CEA) is in place, as will be detailed in the to-be-prepared Remedial Action Permit.

The NLF is currently in Interim Status and closure is anticipated to be completed by 2020, pursuant to the requirements for RCRA landfills specified in 40 CFR 265.310 (Landfills). The NLF contents will be managed as Hazardous Materials, meeting the RCRA treatment requirements and land disposal restrictions of 40 CFR 268 – Land Ban Restrictions. Closure plans were submitted to the NJDEP in December 2003 and March 2006 with revisions submitted in November 2007. The NJDEP indicated in June 2009 that sufficient information existed to proceed with preparation of the closure plan. Therefore, Hess submitted to USEPA/NJDEP, in October 2012 a Remedial Investigation Report (RIR).

1.4 DESCRIPTION OF AOC-1: NORTH LANDFARM

The NLF is a land treatment system located near the central northeast property boundary, encompassing approximately 0.33 acres. It was constructed of diked walls with a silt and clay

liner comprised of dredged fill material and native marsh soils. The NLF was developed in 1974 by constructing an above-grade earthen dike, 200 feet long and 75 feet wide, in the northwest corner of the existing raised earthen dikes protecting the area around AST 7945. The bottom of the NLF is natural soils with some clay.

1.5 REMEDIAL ACTION OBJECTIVE

The RAW/PCMP indicated that some soils at the Site are impacted with total petroleum hydrocarbons (TPH), VOCs, semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and metals, with discrete concentrations greater than the applicable soil remediation standards. The groundwater constituent of concern (COCs) include metals, based on historical groundwater analytical results, as well as SVOCs, VOCs, and PCBs due to historic soil analytical results. The Remedial Action Objective (RAO) for soils is to isolate hazardous waste constituents within the RCRA unit limits beneath the low permeability cap in order to prevent human exposure and contaminant migration outside of the unit; as well as to eliminate any future impacts to groundwater. The RCRA unit Deed Restriction will prevent soil disturbances; and post closure cap maintenance and ground water monitoring will ensure that the cap remains protective as designed. The groundwater ingestion pathway will be addressed independently of this document via establishment of a Classification Exception Area (CEA).

1.6 REMEDY DESCRIPTION

As discussed previously, a low permeability cap is proposed as the remedial action to address the direct contact pathway for potential human health and ecological receptors. The cap system will be comprised of multiple layers of geosynthetic and earthen materials, designed to both shed direct runoff from stormwater as well as to drain percolation that reaches the surface of the low permeability components of the system. The components of the cap system are described in greater detail in Section 2.2.

1.7 PERMIT REQUIREMENTS

Implementation of the soil remediation may require Federal, State and local agency authorizations, permits and/or approvals. The specific type of Federal, State or local authorizations required and associated permit conditions(s) are dictated by the nature of the activity and its location. Prior to the completion of permit applications, a pre-application conference with the Freehold Soil Conservation District (SCD) and NJDEP's Office of Permit Coordination and Environmental Review (PCER) will be initiated to review all regulatory requirements for the projects.

The following is a summary of the permits that are currently anticipated for this project:

- A Soil Erosion and Sediment Control Plan including a Stormwater Pollution Prevention Plan (SPPP) is required by Freehold SCD for projects with soil disturbance more than 5,000 square feet;

- Construction Activity Stormwater General Permit (GP) 5G3 in accordance with New Jersey's Stormwater Management Rules [New Jersey Administrative Code (N.J.A.C.) 7:8] are implemented by the NJDEP. The GP 5G3 controls stormwater discharges to surface water from certain construction activities, including clearing, grading and excavating. The GP 5G3 may be applicable for the closure of NLF as the regulation states that a landfill may be deemed eligible when a written determination is made by the NJDEP that the permit requirements are sufficient to control the construction activities. The NJDEP has the ability to authorize construction activity when a determination is made that the GP 5G3 requirements will protect the quality of the waters of the State. If NJDEP determines that the GP 5G3 is not sufficient, then an individual NJPDES Industrial Stormwater Permit will be required.
- In accordance with N.J.A.C. 7:13, a Flood Hazard Area individual permit is required as the project is located within the limits of the Federal Emergency Management Agency (FEMA) preliminary 100-year floodplain Base Flood Elevation;
- A Coastal Zone Management permit is required for all regulated activities landward of the mean high water line as required by N.J.A.C. 7:7-6.11. The unnamed tributary to the Arthur Kill is located in proximity to the NLF. Based on the proposed activity and its location within the coastal zone, a Coastal Zone Management GP 11 will be required for the investigation, cleanup, removal, or remediation of hazardous substances;
- A Letter of Interpretation (LOI) from the NJDEP and a GP 4 may be required to authorize activities if there are adjacent freshwater wetlands, transition area, and State open waters in accordance with N.J.A.C. 7:26C; and,
- Per Title V of the Federal Clean Air Act, 40 CFR 70, Air Pollution Control Act [New Jersey Statutes Annotated (N.J.S.A.) 26:2C], and N.J.A.C. 7:27-22, an air pollution control operating permit may be required for operation of the passive gas vent system.

2.0 DESIGN

The RAW/PCMP identified, as part of the overall site remedy, the construction of a low permeability cap system. The cap will eliminate the direct contact pathway for potential human and ecological receptors. The cap will be constructed over the NLF limits. The approximate limits of the NLF were depicted in the RAW/PCMP. The NLF limits were refined using the inside toe of slope of the perimeter dikes that was obtained during the 2019 topographic survey. The NLF is 0.33 acres and its limits are shown on Design Drawing NLF-C-101. The limit of disturbance is approximately 0.95 acres.

2.1 PRE-DESIGN ACTIVITIES

A geotechnical investigation and field survey of existing conditions were performed to support the remedial action design activities. A summary of the related activities and findings is presented below.

2.1.1 Geotechnical Investigation

The geotechnical field investigation activities were completed from April 22, 2019 through April 26, 2019 and geotechnical laboratory testing subsequently conducted to obtain information regarding the lithology, consistency, geotechnical index properties, and compressibility of materials located within and along of the perimeter of NLF.

Hollow-stem auger borings KB19-01, KB19-02, KB19-03, KB19-04, and KB19-05 and their respective offset borings were located within and outside of the dikes defining NLF. Hollow-stem boring locations are shown on Figure 1 of Appendix A. The geotechnical investigation report, including a detailed description of the geotechnical field investigation and geotechnical laboratory testing program, daily field activity logs, photographs, boring logs, a summary of geotechnical laboratory test results, and geotechnical laboratory data, are provided in Appendix A.

2.1.2 Field Survey

Ground surface topography, physical features, and the geotechnical boring and boring offset locations were field-surveyed by a surveyor licensed in the state of New Jersey (DPK Consulting Land Surveyors of Piscataway, New Jersey). Survey activities were conducted during April 2019. The survey references the New Jersey State Plane Coordinate System, NAD83 and North American Vertical Datum of 1988 (NAVD88). The surveyor's map indicating ground surface topography and exposed surface physical features and information obtained from the figures included in the RAW/PCMP were used to prepare the existing site conditions plan provided on Design Drawing NLF-C-101. The grid coordinates and ground surface elevation for each geotechnical boring are provided on their respective boring log.

2.2 BASIS OF DESIGN

The design of the NLF cap system is consistent with the USEPA-recommended final cover design for RCRA Subtitle C facilities as described in EPA 625/4-91/025, "Design and Construction of RCRA/CERCLA Final Covers" and updated in EPA 540-R-04-007, "(Draft) Technical Guidance for RCRA/CERCLA Final Covers." The cap system components, with nomenclature used in the USEPA guidance underlined, are as follows:

- Bedding/Foundation Layer – select landfarm and perimeter dike materials, or imported common fill as necessary, regraded and compacted with a (pre-settlement) surface slope of four percent, sloped downward toward the landfarm southwest limit;
- Gas Collection Layer – geonet with lower geotextile;
- Hydraulic Barrier – geosynthetic clay liner (GCL);
- Hydraulic Barrier – 40 mil liner low density polyethylene (LLDPE) geomembrane;
- Drainage Layer – geonet, with single- or double-sided geotextile;
- Protection Layer – 18-inch thick layer of common fill;
- Non-woven Geotextile; and,
- Surface Layer – 6-inch thick layer of coarse aggregate with a (pre-settlement) surface slope of four percent, sloped downward toward the landfarm southwest limit.

2.3 FINAL DESIGN

Design calculations were prepared and are included as Appendix B. Design Drawings were prepared to depict the proposed installation, and are included as Appendix C. Technical Specifications were also prepared to identify the material, installation, and testing requirements associated with construction of the cap; the Technical Specifications are included as Appendix D.

The proposed grading plan shown on Design Drawings NLF-C-104 and NLF-C-105 was designed to:

- minimize the off-site common fill material quantity required to achieve the subgrade surface with minimum 4 percent design slope;
- minimize the potential adverse impact of settlement and differential settlement due to consolidation of the underlying soil (i.e. peat layer) by minimizing the imported material quantities and extent of regrading;
- provide 3 percent minimum post-consolidation grades to promote stormwater runoff;
- retain the form and function of the existing secondary containment dike for AST 7945; and,
- minimize reduction to the storage capacity of the AST 7945 secondary containment system.

Additional details of the cap system design are provided in the Design Drawings, in addition to other construction aspects of the work, such as erosion and sediment control. Design calculations were completed for the consolidation settlement of underlying soils, differential settlement of the

cap, veneer stability analyses of the flatter, plateau and steeper 3H:1V sideslope portions of the cap, geosynthetic materials selection, and material quantity calculations. Design calculations are provided in Appendix B. A more detailed description of the proposed cap materials and associated design features for the NLF cap is provided in subsequent sections.

2.3.1 Subgrade Preparation

The NLF will be cleared and grubbed as necessary, and the Bedding/Foundation Layer material will be placed to the grades shown on the subgrade grading plan (Design Drawing NLF-C-104). Existing dike and/or landfarm materials will be re-used to the maximum extent practical, and off-site borrow material will be obtained as necessary to achieve the subgrade elevations. In areas where excavation of existing dike and/or landfarm materials is required to achieve design grades the resultant surface will be proof-rolled and inspected for the presence of sharp objects or deleterious materials. If sharp objects or deleterious materials are not observed, the surface will be deemed acceptable for overlying cap system placement. If the surface is unacceptable, it will be excavated to a depth of an additional 12 inches and replaced with suitable Bedding/Foundation Layer material.

The grades are based on providing a final cap that fully covers the limits defined by the inside toe of slope of the existing perimeter dike. In general, the surface of the proposed subgrade will "tie into" the existing perimeter dikes at approximately elevation 9 feet (NAVD88) on the southwestern side of NLF, and gradually rise to approximately elevation 15 feet (NAVD88) on the northeastern side of NLF. The pre-settlement design slope of the subgrade and final cap surface is four percent. Based on the consolidation settlement calculations provided in Appendix B it is anticipated that settlement may result in a decrease in surface slope of less than one percent resulting in a minimum post-settlement slope of three percent. The minimum post-settlement slope is therefore in conformance with the criteria suggested in USEPAs "Technical Guidance for RCRA/CERCLA Final Covers" for cap drainage considerations.

2.3.2 Cap Components

The cap will be installed to the limits shown on Design Drawing NLF-C-105. Details of the cap installation are provided on Design Drawings NLF-C-502 and NLF-C-503. The components of the cap system are described below:

- The Bedding/Foundation Layer will be placed in compacted lifts and will consist of landfarm material with a specified maximum particle size. The subgrade will be proof-rolled prior to receiving subsequent lifts. If imported fill is required the material will meet the same specification.

- A Geocomposite Gas Collection Layer will be placed above the Bedding/Foundation Layer to allow for the evacuation of gas build-up, if any. The Geocomposite Gas Collection Layer will consist of geonet with a nonwoven needle-punched geotextile on the bottom

side to prevent clogging. The passive gas management system will be monitored by periodically measuring combustible gas concentrations from the passive gas vents using a direct reading field instrument. The anticipated threshold is 500 parts per million (ppm) greater than background concentrations, consistent with 40 CFR 264.1054. The Geocomposite Gas Collection Layer is a passive system that will collect and convey gas to vertical riser outlets and vent to the atmosphere.

- A Hydraulic Barrier consisting of a geosynthetic clay liner (GCL) will be provided to limit the percolation of water through the cap system and promote drainage in the overlying layers. This lower hydraulic barrier layer will be comprised of a reinforced GCL consisting of a layer of sodium bentonite, with a permeability of roughly 5×10^{-9} centimeters per second (cm/sec), between two nonwoven needle-punched geotextiles, stitch-bonded through the bentonite. A woven geotextile may be used as the top geotextile in lieu of a nonwoven needle-punched geotextile.

- A Hydraulic Barrier consisting of 40 mil LLDPE geomembrane will be installed on top of the GCL. The primary function of the geomembrane is to provide an additional hydraulic barrier layer above the landfarm materials, to further limit infiltration of precipitation into the NLF. The geomembrane may be smooth or textured.

- The Geocomposite Drainage Layer will convey water that infiltrates through the cover soil (i.e. coarse aggregate Surface Layer and common fill Protection Layer) to the perimeter limits of the AOC, reduce saturation of the cover soil layer, and minimize the head on the geomembrane. The Geocomposite Drainage Layer will consist of geonet with nonwoven needle-punched geotextile on one or both sides to prevent clogging.

- The 18-inch Protection Layer functions to protect underlying layers from freeze/thaw cycles, wet/dry cycles, and intrusions such as burrowing animals or plant roots. It also reduces water infiltration into underlying cap system layers. It will consist of common fill from an off-site borrow source.

- A non-woven geotextile with a weight of 6 ounces per square yard (oz/sy) will function as a Separation Layer between the Protection Layer and the coarse aggregate Surface Layer.

- The Surface Layer functions to stabilize the surface, resist erosion by water and wind, provide a biotic barrier to burrowing animals, with a readily maintainable surface. A 6-inch layer of coarse aggregate will serve as the surface layer. The coarse aggregate material will be an New Jersey Department of Transportation (NJDOT) No. 1 coarse aggregate (having a maximum particle size of 3-1/2 inches) at the perimeter terminus of the cap and NJDOT No. 2 or 3 coarse aggregate (having a maximum particle size of 2-1/2 inches and 2 inches respectively) on the top plateau surface. The surface layer will be completed to the grades shown on Design Drawing NLF-C-105.

2.3.3 Stormwater and Erosion

The NLF is bounded to the northeast and northwest by the secondary containment dike of AST 7945. As shown on Design Drawing NLF-C-105, the majority of stormwater runoff will drain to the outside edge of the cap at its southwestern limit as sheet flow with significantly smaller stormwater runoff volume draining to the southeastern and a portion of the northeastern limits as sheet flow. All stormwater runoff discharges to within the secondary containment dike of AST 7945. The subcatchment drainage area and slope length of the plateau portion of the cap system sloped at 4 percent is 0.33 acres and 101 feet respectively. The average annual soil loss for the plateau area is 0.32 tons/acre/year based on a conservative analysis using the Universal Soil Loss Equation, which is less than USEPA's 2 tons/acre/year criteria. The average annual soil loss for the 3H:1V cap sideslope area is 3.2 tons/acre/year based on a conservative analysis using the Universal Soil Loss Equation. The maximum slope for the 3H:1V sideslope is approximately 19 feet in length and 0.01 acres in area and is therefore insignificant. The weighted overall annual soil loss for the cap is 0.4 tons/acre/year which is less than USEPA's 2 tons/acre/year criteria. The Universal Soil Loss calculations are provided in Appendix B.

3.0 POST-CONSTRUCTION OPERATIONS AND MAINTENANCE

Post-closure operations and maintenance activities will meet the requirements contained in 40 CFR 265.117 through 40 CFR 265.120. In accordance with the RAW/PCMP these activities will:

- Maintain the integrity and effectiveness of the final cap, including making repairs to the cap as necessary to correct the effects of settling, subsidence, erosion, or other events;

- Maintain and monitor the passive gas management system. Periodically measure combustible gas concentrations from the passive gas vents using a direct reading field instrument. The anticipated threshold is 500 ppm greater than background concentrations, consistent with 40 CFR 264.1054.

- Maintain and monitor the groundwater monitoring system and comply with all other applicable requirements of subpart F of this part; and,

- Prevent run-on and run-off from eroding or otherwise damaging the final cap.

4.0 PROJECT SCHEDULE

An anticipated project schedule is provided as Figure 4-1. The schedule identifies important milestones which must be achieved to advance the project from design to construction, and ultimately through final construction reporting and regulatory approval. Task durations were estimated based upon experience with other similar projects and may vary based on regulatory review duration, permitting, weather conditions during construction, etc.

5.0 CONSTRUCTION COST ESTIMATE

A construction cost estimate is provided as Appendix E. The cost estimate includes component costs on a line item basis, including line item descriptions, quantities, unit prices, and subtotal line item costs.

6.0 REFERENCES

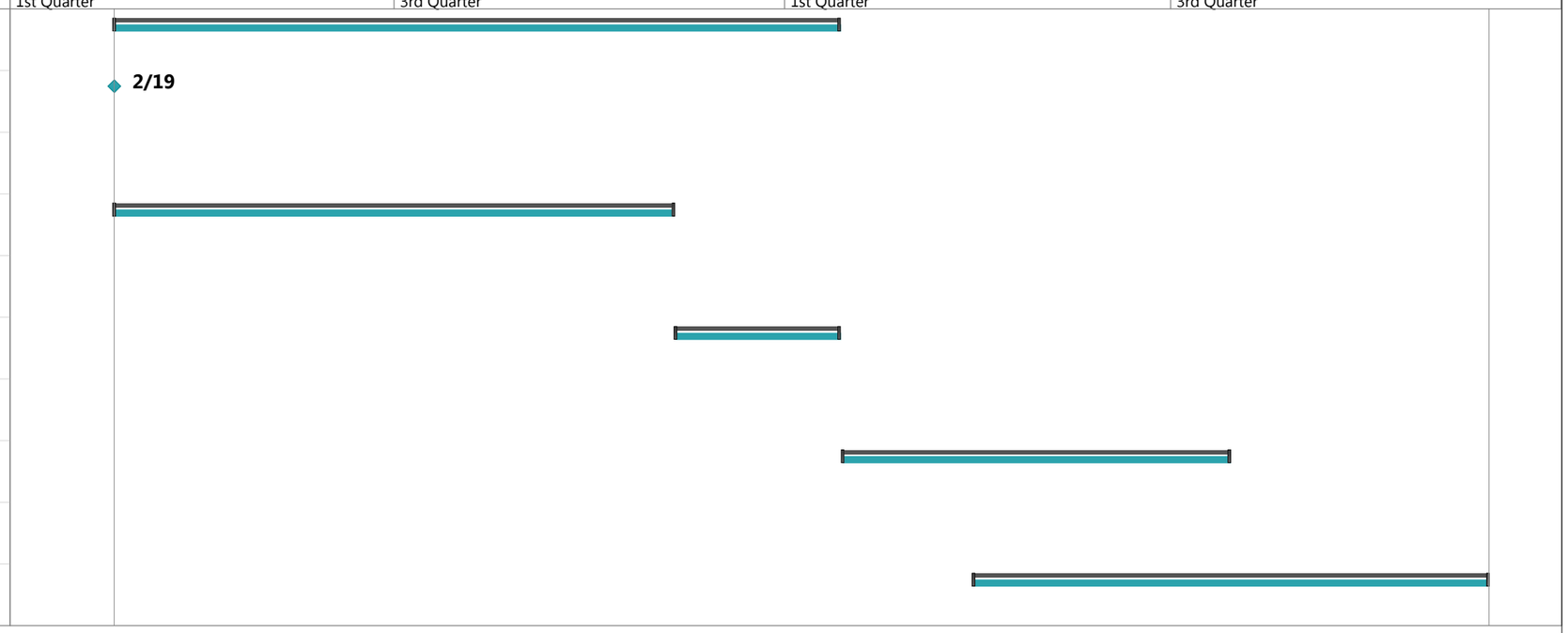
Earth Systems Environmental Engineering (Earth Systems), 2016. Remedial Action Workplan/Post-Closure Monitoring Plan, AOC-1: North Landfarm, 750 Cliff Road, Port Reading, Middlesex County, New Jersey, NJDEP PI# 006148, ISRA Case No. E20130449, EPA ID No. NJD045445483. Prepared for Hess Corporation, West Trenton NJ. September 26.

Delta Consultants, 2007. RCRA Closure Plan for North & South Landfarms: Hess Corporation – Port Reading Refinery, 750 Cliff Road, Port Reading, New Jersey, NJDEP Case Number NJD045445483. Prepared for Mr. Donald G. Bull, Senior Specialist, Hess Corporation – Port Reading Refinery, 1 Hess Plaza, Woodbridge, NJ 07095. Revision 1 – November 15, 2007.

FIGURES

Table 4-1: Project Schedule
Soil Remedial Action Design
AOC-1: North Landfarm
Hess Corporation - Former Port Reading Refining Facility
Port Reading, Middlesex County, New Jersey

ID	Task Name	Duration	Start
1	Soil Remedial Action Design	**354 days**	**2/19/19**
2	Notice-to-Proceed	0 days	2/19/19
3			
4	90% Soil Remedial Action Design	**273 days**	**2/19/19**
14			
15	**100% Soil Remedial Action Design**	**80 days**	**11/10/19**
25			
26	Permits / Approvals / Authorizations	**189 days**	**1/28/20**
31			
32	Remedial Construction	**251 days**	**3/29/20**



Project: Alt 1
Date: 9/5/19

Task Split Milestone Summary

APPENDIX A

GEOTECHNICAL INVESTIGATION REPORT

GEOTECHNICAL INVESTIGATION REPORT
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AOC-1: NORTH LANDFARM

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FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

Prepared for:

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July 10, 2019

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1.0 INTRODUCTION

Key Environmental, Inc. (KEY) has prepared this Geotechnical Investigation Report in accordance with the Geotechnical Investigation Work Plan for the North Landfarm (NLF) under subtask 1.02 of KEY's proposal to Earth Systems Environmental Engineering (Earth Systems) dated January 22, 2019.

The objective of the geotechnical investigation and subsequent geotechnical laboratory testing was to obtain information regarding the lithology, consistency, geotechnical index properties, and compressibility of materials located within and along the perimeter of the NLF. The information obtained during the geotechnical investigation and laboratory testing program will be used to support preparation of the Soil Remedial Action Design (RAD) for the NLF.

2.0 GEOTECHNICAL INVESTIGATION

The geotechnical field investigation activities were completed from April 22, 2019 through April 26, 2019, with oversight provided by a KEY field geologist. Drilling was performed by Uni-Tech Drilling Company, Inc. (Uni-Tech) of Bridgewater, New Jersey under subcontract to Earth Systems. Earth Systems provided instruction and direction to Uni-Tech pertaining to procedures for access, utility clearance and locating, equipment and personnel decontamination, drilling equipment decontamination procedures within and between borings, boring abandonment, restoration, investigation derived waste (IDW) management, and post-installation survey.

Health and Safety

KEY's field activities were conducted in accordance with Earth Systems' Site-specific Health and Safety Plan (HASP) (Earth Systems, 2018). All personnel had current HAZWOPER training, participated in a kick-off health and safety meeting, and attended daily tailgate safety meetings. Uni-Tech provided personal protective equipment (PPE) for their workers, and disposable PPE for the KEY geologist and Site visitors. PPE requirements are identified in Earth Systems' HASP.

Utility Location and Clearance

Prior to the installation of the geotechnical borings, underground utilities were surveyed and marked out by an underground utilities locating subcontractor coordinated by Earth Systems. Ground penetrating radar was used to detect underground utilities within and around the NLF.

The initial 6 feet or 8 feet of hollow-stem auger borings were completed on April 22 by Uni-Tech using "soft dig" techniques (i.e., air-knife and hand auger) in accordance with Hess Corporate EHS & SR Standard titled "Pre-Clearing and Remediation Drilling" (Hess, 2013).

Hollow-Stem Auger Borings

The hollow-stem auger borings were proposed within the NLF and along the four dikes forming the NLF. One boring was proposed within the NLF limits and four borings were proposed along the dikes forming the NLF. The hollow-stem auger boring location proposed northeast of the NLF could not be completed at its proposed location due to space constraints and was therefore relocated to lie within the NLF limits. The proposed hollow-stem auger boring located within the NLF were relocated to the northwest because the southeastern half of the NLF was inundated and inaccessible to the ground penetrating radar equipment. Hollow-stem boring locations are shown on Figure 1.

Uni-Tech utilized a track mounted Central Mine Equipment (CME) Model 55LC drill rig with 4.25-inch inside diameter hollow stem augers to advance the borings. Vane shear tests were performed and thin-walled tube samples were collected in borings offset approximately 5 to 6 feet away from hollow-stem auger borings KB19-01, KB19-02 and KB19-03. Borings were completed in accordance with ASTM D6151. Below the "soft dig" depth, borings were continuously sampled with a split barreled sampler ("split-spoon") in accordance with ASTM D1586 or thin-walled tubes were advanced in accordance with ASTM D1587. The split-spoon sampler was advanced through FILL material and underlying PEAT and sandy soils until standard penetration test (SPT) "N" values were greater than or equal to 10. The KEY field geologist field-screened the breathing zone and each split-spoon sample immediately upon opening with a photo-ionization detector (PID) calibrated and provided by Earth Systems. The materials encountered were classified by the KEY field geologist in accordance with ASTM D2488 using the Unified Soil Classification System (USCS). A physical description of each split spoon sample, standard penetration test "N-value," and field screening results were recorded and are presented on the boring logs.

In-situ shear strength testing was conducted above the thin-walled tube test locations using a vane shear testing apparatus in accordance with ASTM D2573. The vane shear testing apparatus was manufactured by Acker and utilized a 2 inch diameter vane and a 12 inch lower force arm. Vane shear test parameters and results were recorded by the KEY field geologist and presented on the boring logs. Split-spoon samples were obtained from each split-spoon, placed in labeled glass jars, and sealed with lids to minimize moisture loss.

The sample jars were maintained onsite until demobilization, transported offsite to KEY's Carnegie, Pennsylvania office, and jar samples selected for geotechnical laboratory testing. Thin-walled tube samples were sealed and transported to KEY's Carnegie, Pennsylvania office for examination. After examination, split-spoon jar samples and thin-walled tube samples were submitted to Geotechnics, Inc. of East Pittsburgh, Pennsylvania for geotechnical testing. Daily

field activity logs of the geotechnical investigation activities are provided in Appendix A. Results of the geotechnical laboratory testing are summarized on Table 1 and presented in Appendix B.

Lithology

The dominant lithology of the NLF generally consists of FILL material from the ground surface to approximately 11.8 to 15 feet below ground surface (ft bgs). Below the FILL material, black to greenish brown silty to clayey estuarine and salt marsh deposit with trace to abundant organics and referred to herein as a PEAT layer is present to approximately 23.8 to 29 ft bgs. Below the PEAT layer there is gray SAND AND rounded to angular GRAVEL. A summary of the lithology and standard penetration test "N-value" of the NLF is presented in cross sections A-A' and B-B' on Figure 2. Geotechnical boring logs are provided in Appendix C. Borings were abandoned under the direction of Earth Systems onsite personnel in accordance with applicable Earth Systems SOPs.

IDW Management

The IDW that was generated from the test boring effort included soil cuttings and displaced groundwater which was drummed and staged inside the NLF limits for management by Earth Systems.

3.0 SITE SURVEY

The geotechnical boring locations were staked after completion and then surveyed by DPK Consulting Land Surveyors of Piscataway, New Jersey. Survey activities were conducted on April 25, 2019 to establish survey control and reference points, survey Site topography and physical features including boring locations. The horizontal locations were reported in the New Jersey State Plane Coordinate System in units of feet and referenced to the North American Datum of 1983 (NAD83). The elevation survey results were also reported in feet and referenced to the North American Vertical Datum of 1988 (NAVD88). The grid coordinates and ground surface elevation for each boring are provided on the respective boring log.

4.0 REFERENCES

American Society for Testing and Materials International (ASTM):

- D1586-11 Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
- D1587-15 Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes

- D2488-17 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)
- D2573-15 Standard Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils
- D4220-14 Standard Practices for Preserving and Transporting Soil Samples
- D6151-15 Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling

Earth Systems Environmental Engineering (Earth Systems), 2018. Project Health and Safety Plan (HASP), HESS Port Reading, Woodbridge Township, Middlesex County, New Jersey. February 23.

Hess, 2013. Standard protocol titled "Pre-Clearing and Remediation Drilling" prepared by Hess Corporate Environment, Health, Safety & Social Responsibility (EHS & SR) Organization, Remediation Department. November 21.

TABLES

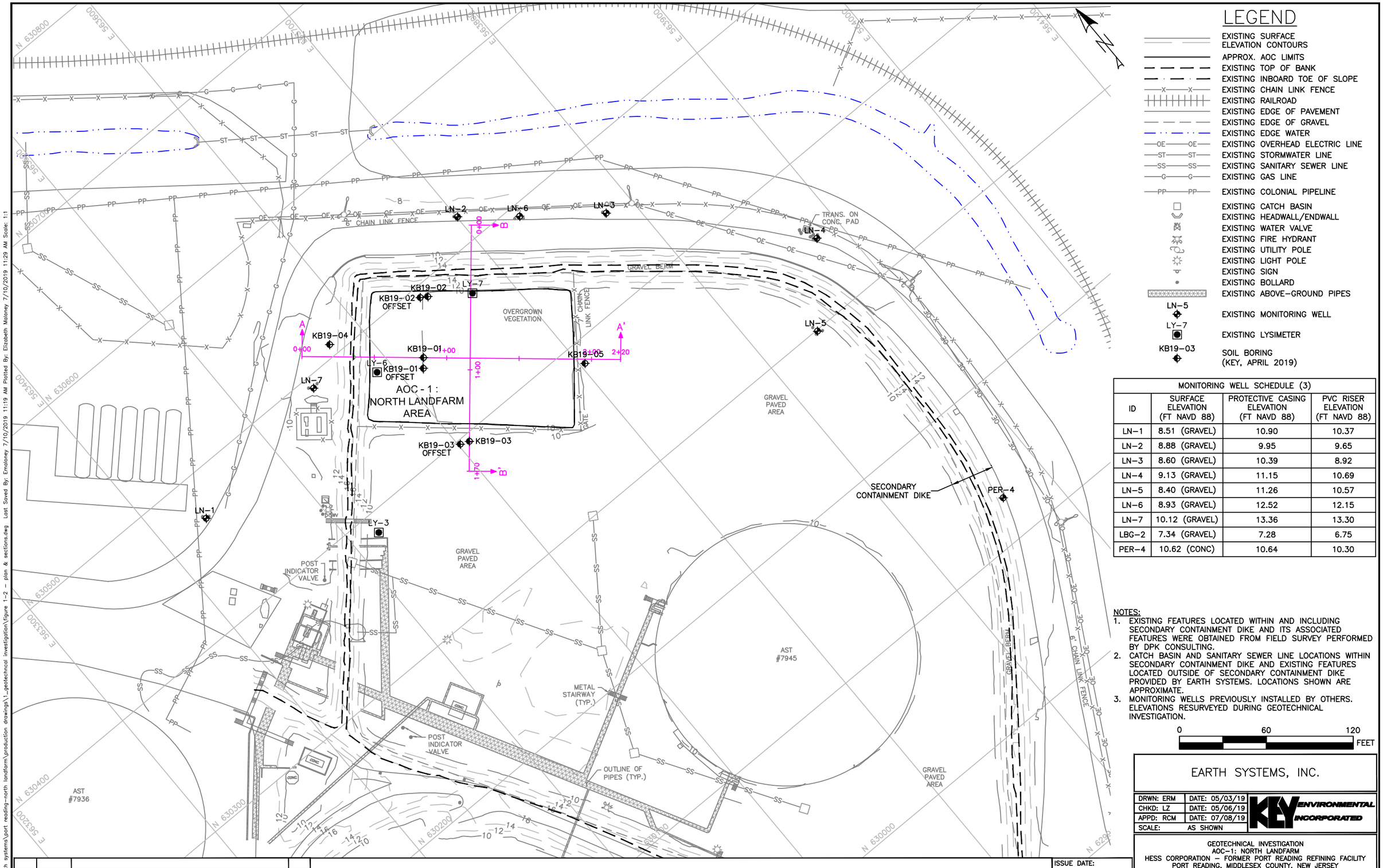
TABLE 1
SUMMARY OF GEOTECHNICAL LABORATORY TEST RESULTS
AOC-1: NORTH LANDFARM
HESS CORPORATION - FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

Boring ID	Sample ID	Sample Depth Interval (ft bgs)	PHYSICAL PROPERTIES											ENGINEERING PROPERTIES			
			Water Content ASTM D2216	Sieve ASTM D422		Hydrometer ASTM D422	Atterberg Limits (%) ASTM D4318			Bulk Density ASTM D7263-09	Specific Gravity ASTM D854	Organic Matter Content ASTM D2974B	USCS ASTM D2487 or ASTM D2488 (1)	Tube Log USACE	1-Dimensional Consolidation ASTM D2435			
			(%)	Passing No. 4 (%)	Passing No. 200 (%)	(%)	LL[2]	PL	PI	(pcf)		(%)			e_o	C_c	C_r	C_v
KB19-01 offset	ST-1A	15.2-15.7	113.5	97.09	70.32	26.32% silt 44.00% clay/colloids	75/56	38	37	85.1 wet / 42.1 dry	2.50	4.9	OH (gray elastic SILT w/sand)	X	3.16	0.639	0.111	(4)
KB19-01 offset	ST-1B	16.7-17.2	70.7	99.63	97.27	NT	75/55	37	38	94.6 wet / 55.6 dry	NT	4.8	OH (gray elastic SILT)		NT	NT	NT	NT
KB19-02 offset	ST-1A	19.2-19.7	84.3	95.59	68.86	31.36% silt 37.50% clay/colloids	71/50	36	35	96.6 wet / 57.5 dry	2.48	8	OH (gray sandy elastic SILT)	X	1.34	0.339	0.026	(4)
KB19-02 offset	ST-1B	20.7-21.1	76.3	99.96	96.13	NT	79/55	38	41	94.7 wet / 53.8 dry	NT	5.4	OH (gray elastic SILT)		NT	NT	NT	NT
KB19-01	SS03	12.0-14.0	70.1	NT		NT	NT	NT	NT	NT	NT	4.8	sandy silty clay		NT	NT	NT	NT
KB19-01	SS04	14.0-16.0	81.3	NT		NT	NT	NT	NT	NT	NT	6.9	sandy silty clay		NT	NT	NT	NT
KB19-01	SS07	20.0-22.0	85.8	NT		NT	NT	NT	NT	NT	NT	7.6	sandy silty clay		NT	NT	NT	NT
KB19-01	SS09	24.0-26.0	90.7	NT		NT	NT	NT	NT	NT	NT	8.6	sandy silty clay		NT	NT	NT	NT
KB19-02	SS05	16.0-18.0	136.4	NT		NT	NT	NT	NT	NT	NT	23.6	sandy silty clay		NT	NT	NT	NT
KB19-02	SS06	18.0-20.0	78.1	NT		NT	NT	NT	NT	NT	NT	7.1	sandy silty clay, trace organics		NT	NT	NT	NT
KB19-02	SS08	22.0-24.0	62.9	NT		NT	NT	NT	NT	NT	NT	6.8	sandy silty clay, trace organics		NT	NT	NT	NT
KB19-03	SS04	14.5-15.0	30.8	NT		NT	NT	NT	NT	NT	NT	2.6	sandy silty clay w/gravel		NT	NT	NT	NT
KB19-03	SS04	15.0-16.0	82.0	NT		NT	NT	NT	NT	NT	NT	7.7	sandy silty clay, trace organics		NT	NT	NT	NT
KB19-03	SS06	18.0-20.0	96.3	NT		NT	NT	NT	NT	NT	NT	9.0	sandy silty clay, trace organics		NT	NT	NT	NT
KB19-04	SS05/SS06/SS07	16.0-22.0	77.1	98.90	88.55	NT	118/60	40	78	NT	NT	6.1	OH		NT	NT	NT	NT
KB19-05	SS05/SS06/SS07	16.0-22.0	76.5	99.96	96.52	NT	116/60	41	75	NT	NT	5.7	OH		NT	NT	NT	NT

ASTM - American Society for Testing and Materials International.
ft bgs - Feet below ground surface.
NP - Non plastic.
NT - Not tested.
USACE - United States Army Corps of Engineers.
USCS - Unified Soil Classification System.

Notes
(1) ASTM D2487 classification for engineering purposes (USCS) based on laboratory test data. ASTM D2488 description and identification based on visual/manual procedure performed in the laboratory. Refer to boring log for additional information.
(2) Liquid Limit results presented for standard preparation and after oven drying at 110 °C per ASTM D2487 (LL standard preparation / LL oven-dried).
(3) Clay is assumed to be of particle size smaller than 0.005 mm.
(4) Function of test load range. Refer to geotechnical laboratory test results.

FIGURES



LEGEND

- EXISTING SURFACE ELEVATION CONTOURS
- APPROX. AOC LIMITS
- EXISTING TOP OF BANK
- EXISTING INBOARD TOE OF SLOPE
- EXISTING CHAIN LINK FENCE
- EXISTING RAILROAD
- EXISTING EDGE OF PAVEMENT
- EXISTING EDGE OF GRAVEL
- EXISTING EDGE WATER
- EXISTING OVERHEAD ELECTRIC LINE
- EXISTING STORMWATER LINE
- EXISTING SANITARY SEWER LINE
- EXISTING GAS LINE
- EXISTING COLONIAL PIPELINE
- EXISTING CATCH BASIN
- EXISTING HEADWALL/ENDWALL
- EXISTING WATER VALVE
- EXISTING FIRE HYDRANT
- EXISTING UTILITY POLE
- EXISTING LIGHT POLE
- EXISTING SIGN
- EXISTING BOLLARD
- EXISTING ABOVE-GROUND PIPES
- LN-5 — EXISTING MONITORING WELL
- LY-7 — EXISTING LYSIMETER
- KB19-03 — SOIL BORING (KEY, APRIL 2019)

MONITORING WELL SCHEDULE (3)			
ID	SURFACE ELEVATION (FT NAVD 88)	PROTECTIVE CASING ELEVATION (FT NAVD 88)	PVC RISER ELEVATION (FT NAVD 88)
LN-1	8.51 (GRAVEL)	10.90	10.37
LN-2	8.88 (GRAVEL)	9.95	9.65
LN-3	8.60 (GRAVEL)	10.39	8.92
LN-4	9.13 (GRAVEL)	11.15	10.69
LN-5	8.40 (GRAVEL)	11.26	10.57
LN-6	8.93 (GRAVEL)	12.52	12.15
LN-7	10.12 (GRAVEL)	13.36	13.30
LBG-2	7.34 (GRAVEL)	7.28	6.75
PER-4	10.62 (CONC)	10.64	10.30

NOTES:
1. EXISTING FEATURES LOCATED WITHIN AND INCLUDING SECONDARY CONTAINMENT DIKE AND ITS ASSOCIATED FEATURES WERE OBTAINED FROM FIELD SURVEY PERFORMED BY DPK CONSULTING.
2. CATCH BASIN AND SANITARY SEWER LINE LOCATIONS WITHIN SECONDARY CONTAINMENT DIKE AND EXISTING FEATURES LOCATED OUTSIDE OF SECONDARY CONTAINMENT DIKE PROVIDED BY EARTH SYSTEMS. LOCATIONS SHOWN ARE APPROXIMATE.
3. MONITORING WELLS PREVIOUSLY INSTALLED BY OTHERS. ELEVATIONS RESURVEYED DURING GEOTECHNICAL INVESTIGATION.

0 60 120 FEET

EARTH SYSTEMS, INC.

DRWN: ERM	DATE: 05/03/19
CHKD: LZ	DATE: 05/06/19
APPD: RCM	DATE: 07/08/19
SCALE:	AS SHOWN

KEY ENVIRONMENTAL INCORPORATED

GEOTECHNICAL INVESTIGATION
AOC-1: NORTH LANDFARM
HESS CORPORATION – FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

REV #	DATE	DESCRIPTION	APPD

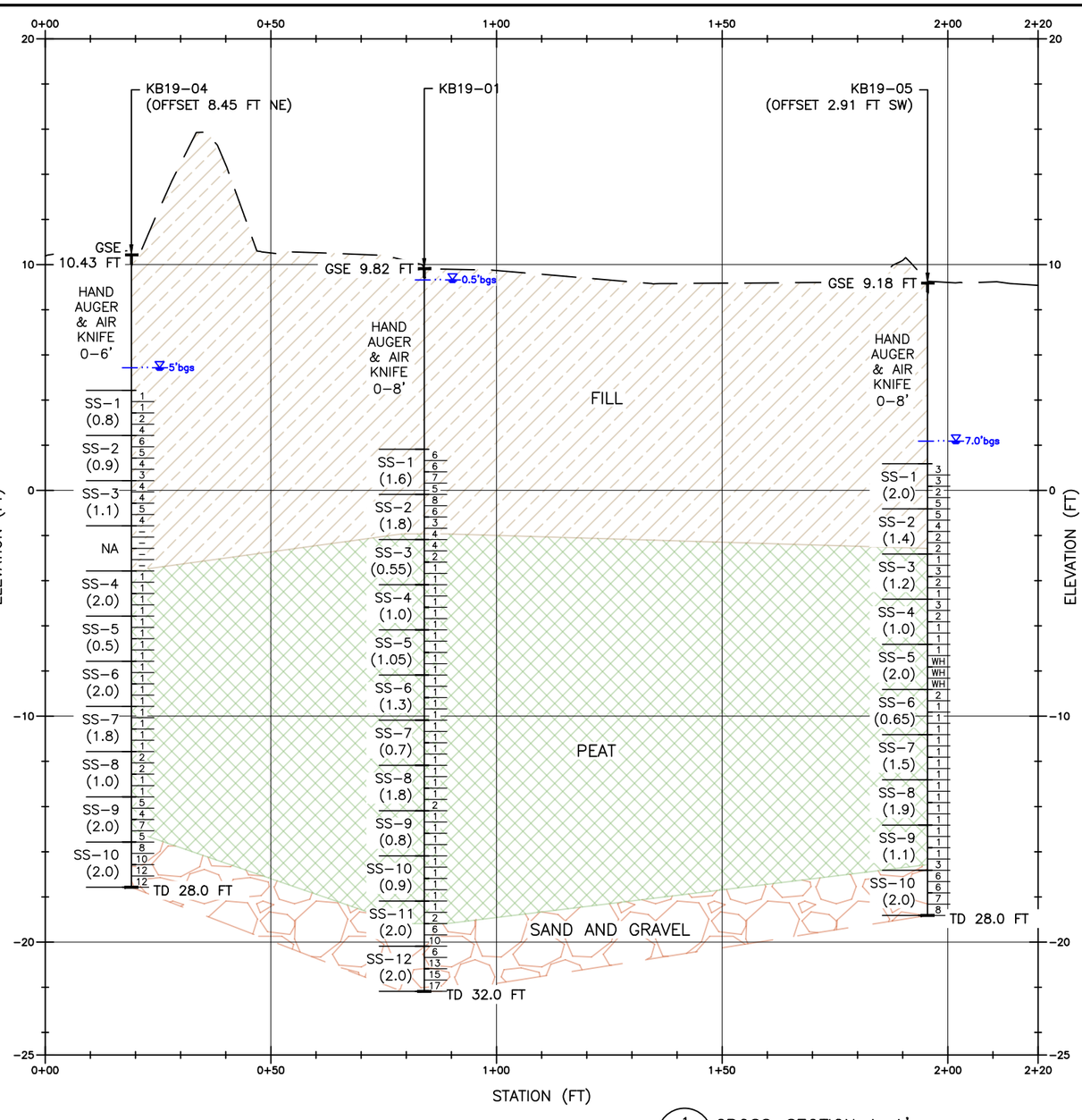
ISSUE DATE:

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

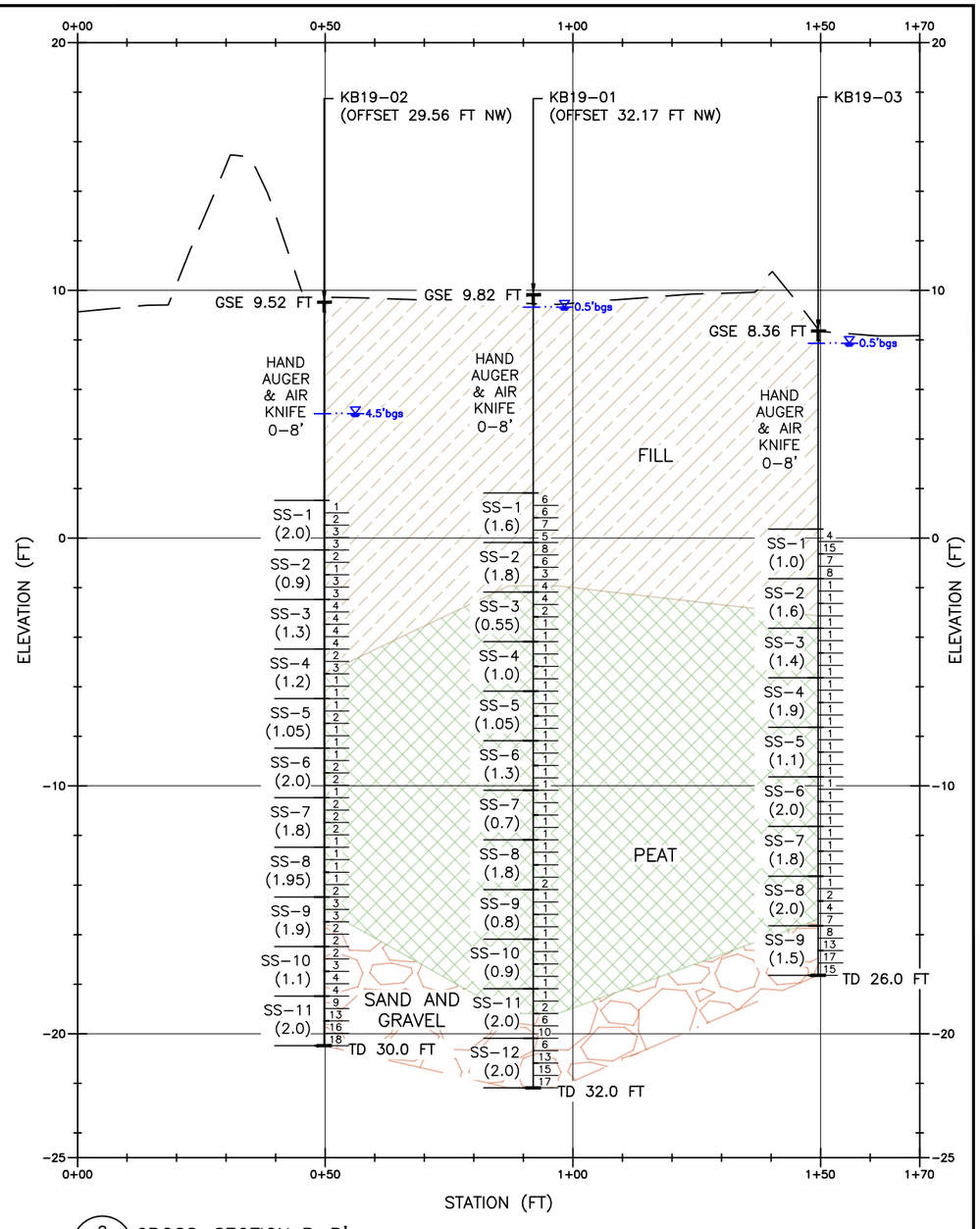
GEOTECHNICAL INVESTIGATION PLAN

PROJECT NO: 19-819

FIGURE 1



1 FIG 2 CROSS-SECTION A-A'



2 FIG 2 CROSS-SECTION B-B'

LEGEND

- EXISTING GROUND SURFACE
- WATER LEVEL AT TIME OF BORING
- T — TOP OF BORING/ GROUND SURFACE
- SS-1 — SPLIT SPOON SAMPLE ID
- (8.4) — RECOVERY OF SPLIT SPOON IN FEET OUT OF 2'
- 1 / WH / 1 / WH — STANDARD PENETRATION TEST BLOW COUNT VALUES
- FILL
- PEAT
- SAND AND GRAVEL
- GSE — GROUND SURFACE ELEVATION
- TD — TOTAL DEPTH

NOTES:

1. REFER TO FIGURE 1 FOR BORING LOCATION PLAN.
2. OFFSET BORINGS ARE NOT SHOWN.

V: 0 6 12 FEET

H: 0 30 60 FEET

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE:

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

EARTH SYSTEMS, INC.

DRWN: ERM	DATE: 05/03/19	KEY ENVIRONMENTAL INCORPORATED
CHKD: LZ	DATE: 05/06/19	
APPD: RCM	DATE: 07/08/19	
SCALE:	AS SHOWN	

GEOTECHNICAL INVESTIGATION
AOC-1: NORTH LANDFARM
HESS CORPORATION – FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

CROSS SECTIONS A-A' AND B-B'

PROJECT NO: 19-819

FIGURE 2

APPENDIX A

Daily Field Activity Logs

DAILY FIELD ACTIVITY LOG
GEOTECHNICAL INVESTIGATION PROJECT #19819-01-02
EARTH SYSTEMS, INC.

NORTH LANDFARM, HESS/BUCKEYE TERMINAL, PORT READING, NJ

OVERSIGHT:	Philip Griffith
WEATHER: *Temperature* *Precipitation*	Cloudy 52°F – 65°F <0.07 inches
CONTRACTORS AND PERSONNEL ON-SITE: *Key Environmental Inc. (KEY)* *Earth Systems* *Unitech Drilling (Earth Systems Subcontractor)*	 Philip Griffith – Geologist Kyle Young - Consultant Bob Hough - Driller Oscar Argaeta – Assist. Driller
EQUIPMENT ON-SITE: *Unitech Drilling* *Earth Systems*	 Atlas Copco XATS 375 Air Compressor with air knife and vacuum attachments Hand auger and post-hole digger equipment Mini Rae 3000 PID meter

ACTIVITIES COMPLETED:

1. KEY on-site at 0750.
2. Earth Systems safety tailgate meeting conducted by Kyle Young. Topics covered included proper PPE, site conditions, safety measures, and operating drilling equipment.
3. Clear KB19-01, KB19-02, KB19-03, and KB19-05 to 8 ft-bgs and KB19-04 to 6 ft-bgs with air knife and hand auger/post hole digger equipment. Prior to arrival on-site, Earth Systems performed Ground Penetrating Radar testing to check for utility lines at the North Landfarm boring locations.
4. Additional offset borings at KB19-01, KB19-02, and KB19-03 were cleared to 8 ft-bgs in preparation for vane shear testing and thin-walled tube sampling.
5. KEY off-site at 1400.

WORK PLANNED:

1. Drill and split spoon sample KB19-05 through overburden (dredge fill), peat layer, and into sand with SPT N-value greater than 10.
2. Time permitting, continue drilling and split spoon sampling KB19-01 and KB19-05.

NOTES/ONSITE ISSUES:

1. PID ambient background/breathing zone readings ranged from 0.1-0.3 ppm (likely from surrounding terminal areas).
2. Drillers to bring glass jars and thin-walled tubes for sampling tomorrow.

PHOTOS ATTACHED:	Yes.

Oversight Signature: Philip Griffith

Date: **April 22, 2019**

Photo Log

Photo 1 – Unitech drillers clearing KB19-03 location with the air knife equipment.

Photo 2 – Unitech drillers clearing KB19-02 location with a hand-auger and post-hole digger.

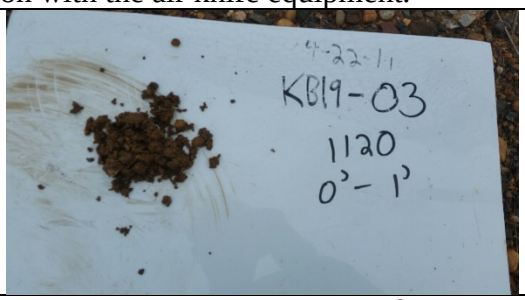


Photo 3 – Hand auger sample taken from KB19-03, represented typical brown fine to medium grained sand seen within the top soil layer of the boring locations.

Photo 4 – Hand auger sample taken from KB19-03, represented typical black silty clay material seen below brown sand at several boring locations.

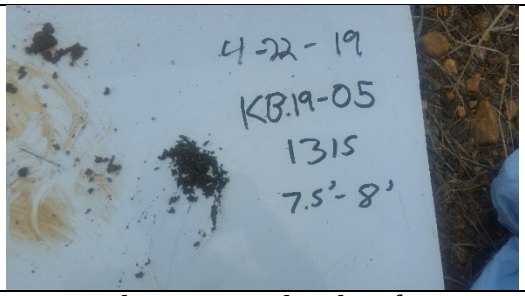


Photo 5 – Hand auger sample taken from KB19-05, represented gray fine to medium grained sand seen below brown sand and black silty clay at several boring locations.

Photo 6 – Soft dig depths were taken by measurements of the hand-auger length reached in the borings.

DAILY FIELD ACTIVITY LOG
GEOTECHNICAL INVESTIGATION PROJECT #19819-01-02
EARTH SYSTEMS, INC.

NORTH LANDFARM, HESS/BUCKEYE TERMINAL, PORT READING, NJ

OVERSIGHT:	Philip Griffith
WEATHER: *Temperature* *Precipitation*	Cloudy 57°F – 77°F 0.00 inches
CONTRACTORS AND PERSONNEL ON-SITE: *Key Environmental Inc. (KEY)* *Earth Systems* *Unitech Drilling (Earth Systems Subcontractor)*	 Philip Griffith – Geologist Kyle Young - Consultant Bob Hough - Driller Eddie Tavarez – Assist. Driller
EQUIPMENT ON-SITE: *Unitech Drilling* *Earth Systems*	 CME 55 track mounted drill rig, 4.25” ID augers and 2” dia x 2 ft split-spoon samplers. Support Skid-Steer loader. Support truck with water container. Mini Rae 3000 PID meter

ACTIVITIES COMPLETED:

1. KEY on-site at 0730.
2. Earth Systems safety tailgate meeting conducted by Kyle Young. Topics covered included site conditions, safety measures, and insects/environmental hazards.
3. Conducted site reconnaissance of area contiguous to secondary containment of Tank 7945 with observations as follows:
   - Dike aggregate surfacing of North Landfarm is 1 to 4 inches in size with a thin layer on top of the dike and approximately 6 inches on the sideslopes. Aggregate surfacing underlain by a silty fm sand base.
   - Fence fabric height surrounding North Landfarm is approximately 7 feet high.
   - AST 7945 is approximately 48 ft in height.
4. Drill and split-spoon sample KB19-05 to 28 ft-bgs and reach bottom of peat and SPT N-value greater than 10.
5. Drill and split-spoon sample KB19-01 to 32 ft-bgs and reach bottom of peat and SPT N-value greater than 10.
6. KEY off-site at 1420.

WORK PLANNED:

1. Take vane shear tests and thin-walled tube sample of KB19-05 offset.
2. Time permitting, drill and split-spoon sample KB19-02 through peat layer into sand below to SPT N-value greater than 10, take vane shear test and thin-walled tube sample of KB19-02 offset.

NOTES/ONSITE ISSUES:

1. PID ambient background/breathing zone readings ranged from 0.1-0.3 ppm (likely from surrounding terminal areas).

PHOTOS ATTACHED:	Yes.

Oversight Signature: Philip Griffith

Date: April 23, 2019

Photo Log

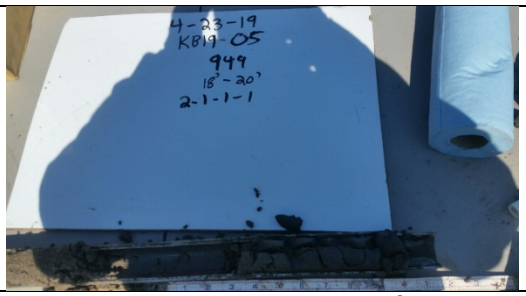
	
Photo 1 – Split-spoon sample taken from KB19-01 at 10 to 12 ft-bgs, represented brown to gray fine to medium grained sand seen above peat layer at KB19-01 and KB19-05.	Photo 2 – Split-spoon sample taken from KB19-05 at 18 to 20 ft-bgs, represented black silty clay/peat layer at KB19-01 and KB19-05.
	
Photo 3 – Split-spoon sample taken from KB19-05 at 26 to 28 ft-bgs, represented gray fine to medium grained sand seen below peat layer at KB19-01 and KB19-05.	Photo 4 – Drillers using the CME 55 track-mounted drill rig to advance the auger at KB19-05.
	
Photo 5 – Dike aggregate surfacing of North Landfarm is 1 to 4 inches in size and approximately 6 inches on the sideslopes.	Photo 6 – AST 7945 is approximately 48 ft high.

	
Photo 7 –Fabric of the North Landfarm fence is approximately 7 ft in height.	

DAILY FIELD ACTIVITY LOG
GEOTECHNICAL INVESTIGATION PROJECT #19819-01-02
EARTH SYSTEMS, INC.

NORTH LANDFARM, HESS/BUCKEYE TERMINAL, PORT READING, NJ

OVERSIGHT:	Philip Griffith
WEATHER: *Temperature* *Precipitation*	Clear 62°F – 71°F 0.00 inches
CONTRACTORS AND PERSONNEL ON-SITE: *Key Environmental Inc. (KEY)* *Earth Systems* *Unitech Drilling (Earth Systems Subcontractor)* *DPK Consulting, LLC*	 Philip Griffith – Geologist Kyle Young - Consultant Bob Hough - Driller Eddie Tavarez – Assist. Driller Oscar Argaeta – Assist. Driller Jake Stuhl - Surveyor
EQUIPMENT ON-SITE: *Unitech Drilling* *Earth Systems* *DPK Consulting, LLC*	 CME 55 track mounted drill rig, 4.25” ID augers, 2” dia x 2 ft split-spoon samplers, Acker vane shear test equipment, and 3” dia x 30” length thin-walled sampling tubes. Support Skid-Steer loader. Support truck with water container. Mini Rae 3000 PID meter Surveying equipment

ACTIVITIES COMPLETED:

1. KEY on-site at 0735.
2. Earth Systems safety tailgate meeting conducted by Kyle Young. Topics covered included site conditions, safety measures, and insects/environmental hazards.
3. KEY and Earth Systems met with DPK Consulting’s surveyor to initiate surveying assignments on-site.
4. Drill and split-spoon sample KB19-02 to 30 ft-bgs and reach bottom of peat and SPT N-value greater than 10.
5. Drill KB19-02 offset for vane shear test and thin-walled tube sample.
   - Vane shear test conducted at depth of 18-19 ft-bgs. Peak strength: approx. 350 in/lb. Remolded strength: approx. 200 in/lb.
   - Thin-walled tube sample collected from depth of 19-21.3 ft-bgs. Recovery of 2.3 ft.
6. Drill KB19-01 offset for vane shear test and thin-walled tube sample.
   - Vane shear test conducted at depth of 14-15 ft-bgs. Peak strength: approx. 200 in/lb. Remolded strength: approx. 100 in/lb.
   - Augers left in place to collect thin-walled tube sample tomorrow.
7. KEY off-site at 1440.

WORK PLANNED:

1. Take thin-walled tube sample of KB19-01 offset.
2. Drill and split-spoon sample KB19-03 through peat layer into sand below to SPT N-value greater than 10, take vane shear test and thin-walled tube sample of KB19-03 offset.
3. Conclude surveying tasks.

NOTES/ONSITE ISSUES:	
1. PID ambient background/breathing zone readings ranged from 0.1-0.3 ppm (likely from surrounding terminal areas). 2. Drillers to bring new thin-walled tubes for sampling tomorrow. 3. DPK unsure of catch basin locations around AST 7945.	
PHOTOS ATTACHED:	Yes.

Oversight Signature: Philip Griffith

Date: **April 24, 2019**

Photo Log

Photo 1 – Split-spoon sample taken from KB19-02 at 8 to 10 ft-bgs, represented brown to gray fine to medium grained sand seen above peat layer.

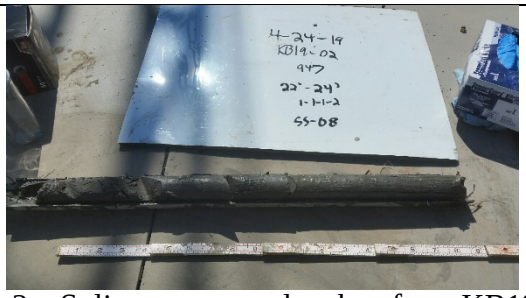


Photo 2 – Split-spoon sample taken from KB19-02 at 22 to 24 ft-bgs, represented black silty clay/peat layer.

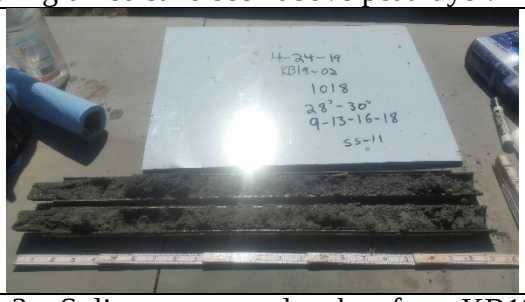


Photo 3 – Split-spoon sample taken from KB19-02 at 28 to 30 ft-bgs, represented gray fine to medium grained sand seen below peat layer.

Photo 4 – Drillers using the Acker Vane Shear test equipment to find peak shear strength at KB19-01 offset.

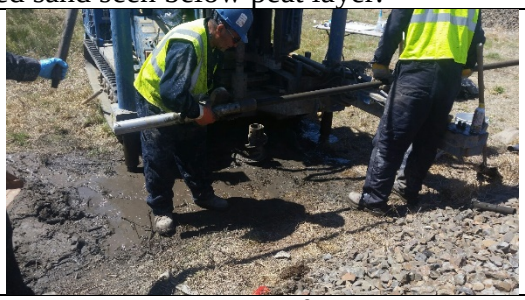


Photo 5 – Drillers setting up for thin walled tube sampling at KB19-02 offset.

DAILY FIELD ACTIVITY LOG
GEOTECHNICAL INVESTIGATION PROJECT #19819-01-02
EARTH SYSTEMS, INC.

NORTH LANDFARM, HESS/BUCKEYE TERMINAL, PORT READING, NJ

OVERSIGHT:	Philip Griffith
WEATHER: *Temperature* *Precipitation*	Partly Cloudy. 50°F – 68°F 0.00 inches
CONTRACTORS AND PERSONNEL ON-SITE: *Key Environmental Inc. (KEY)* *Earth Systems* *Unitech Drilling (Earth Systems Subcontractor)* *DPK Consulting, LLC*	 Philip Griffith – Geologist Kyle Young - Consultant Bob Hough - Driller Eddie Tavarez – Assist. Driller Oscar Argaeta – Assist. Driller Jake Stuhl - Surveyor
EQUIPMENT ON-SITE: *Unitech Drilling* *Earth Systems* *DPK Consulting, LLC*	 CME 55 track mounted drill rig, 4.25” ID augers, 2” dia x 2 ft split-spoon samplers, Acker vane shear test equipment, and 3” dia x 30” length thin-walled sampling tubes. Support Skid-Steer loader. Support truck with water container. Mini Rae 3000 PID meter Surveying equipment

ACTIVITIES COMPLETED:

1. KEY on-site at 0730.
2. Earth Systems safety tailgate meeting conducted by Kyle Young. Topics covered included site conditions, safety measures, and insects/environmental hazards.
3. DPK concludes surveying assignments.
4. Take thin-walled tube sample from KB19-01 offset at depth of 15-17.3 ft-bgs. Recovery of 2.3 ft.
5. Drill and split-spoon sample KB19-03 to 26 ft-bgs and reach bottom of peat and SPT N-value greater than 10.
6. Drill KB19-03 offset for vane shear test and thin-walled tube sample.
   - Vane shear test conducted at depth of 17-18 ft-bgs. Peak strength: approx. 175 in/lb. Remolded strength: approx. 100 in/lb.
   - Thin-walled tube sample collected from depth of 18-20 ft-bgs. Recovery of 1.9 ft.
7. KEY off-site at 1440.

WORK PLANNED:

1. Drill and split-spoon sample KB19-04 through peat layer into sand below to SPT N-value greater than 10.

NOTES/ONSITE ISSUES:

1. PID ambient background/breathing zone readings ranged from 0.1-8.0 ppm (likely from surrounding terminal areas and fuel transfer activities).

PHOTOS ATTACHED:	Yes.

Oversight Signature: Philip Griffith

Date: **April 25, 2019**

Photo Log

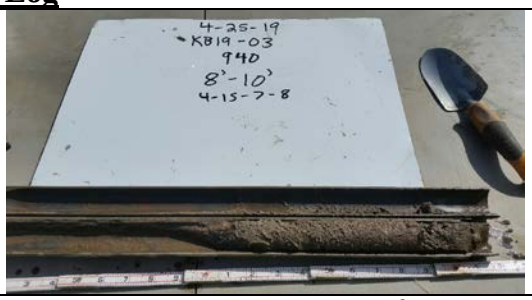


Photo 1 – Split-spoon sample taken from KB19-03 at 8 to 10 ft-bgs, represented brown to gray fine to medium grained sand seen above peat layer.

Photo 2 – Split-spoon sample taken from KB19-03 at 18 to 20 ft-bgs, represented black silty clay/peat layer.

Photo 3 – Split-spoon sample taken from KB19-03 at 24 to 26 ft-bgs, represented gray fine to medium grained sand seen below peat layer.

Photo 4 – Drillers setting up the Acker Vane Shear test equipment at KB19-03 offset.

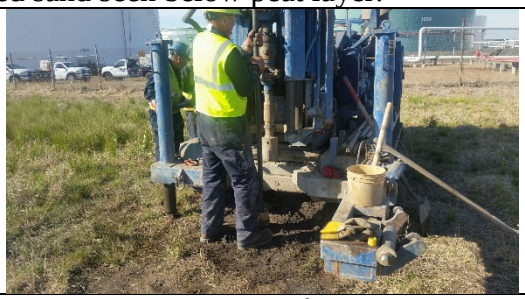


Photo 5 – Drillers setting up for thin walled tube sampling at KB19-01 offset.

DAILY FIELD ACTIVITY LOG
GEOTECHNICAL INVESTIGATION PROJECT #19819-01-02
EARTH SYSTEMS, INC.

NORTH LANDFARM, HESS/BUCKEYE TERMINAL, PORT READING, NJ

OVERSIGHT:	Philip Griffith
WEATHER: *Temperature* *Precipitation*	Cloudy. 50°F – 58°F 0.00 inches
CONTRACTORS AND PERSONNEL ON-SITE: *Key Environmental Inc. (KEY)* *Earth Systems* *Unitech Drilling (Earth Systems Subcontractor)*	 Philip Griffith – Geologist Kyle Young - Consultant Bob Hough - Driller Oscar Argaeta – Assist. Driller
EQUIPMENT ON-SITE: *Unitech Drilling* *Earth Systems*	 CME 55 track mounted drill rig, 4.25” ID augers and 2” dia x 2 ft split-spoon samplers. Support Skid-Steer loader. Support truck with water container. Mini Rae 3000 PID meter

ACTIVITIES COMPLETED:

1. KEY on-site at 0730.
2. Earth Systems safety tailgate meeting conducted by Kyle Young. Topics covered included site conditions, safety measures, and insects/environmental hazards.
3. Drill and split-spoon sample KB19-04 to 28 ft-bgs and reach bottom of peat and SPT N-value greater than 10.
4. Unitech demobilizes from site.
5. KEY off-site at 1110.

NOTES/ONSITE ISSUES:

1. PID ambient background/breathing zone readings ranged from 0.1-0.4 ppm (likely from surrounding terminal areas and fuel transport operations).

PHOTOS ATTACHED:	Yes.

Oversight Signature: Philip Griffith

Date: **April 26, 2019**

Photo Log

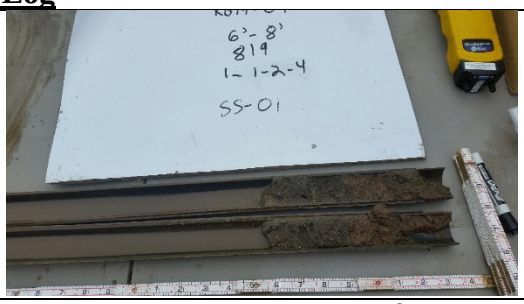


Photo 1 – Split-spoon sample taken from KB19-04 at 6 to 8 ft-bgs, represented brown to gray fine to medium grained sand seen above peat layer.

Photo 2 – Split-spoon sample taken from KB19-04 at 18 to 20 ft-bgs, represented black silty clay/peat layer.

Photo 3 – Split-spoon sample taken from KB19-04 at 26 to 28 ft-bgs, represented gray fine to medium grained sand seen below peat layer.

APPENDIX B

Geotechnical Laboratory Data

SHELBY TUBE UNIT WEIGHT

ASTM D7263-09

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth Pushed (ft):	15.0-17.3
Project No.:	2019-264-001	Shelby Tube No.:	ST-1A & ST-1B
Lab ID:	2019-264-001-001 & 002	Recovery (ft):	2.3

MOISTURE CONTENT

Section Number	**1**	**2**	**3**	**4**	**5**
Tare Number	3123	1489			1516
Weight of Tare & Wet Sample (g)	84.37	602.53			409.36
Weight of Tare & Dry Sample (g)	50.67	414.64			274.61
Weight of Tare (g)	8.21	146.57			142.85
Moisture Content (%)	79.37	70.09			102.27

UNIT WEIGHT

Weight of Tube & Wet Sample (g)		1412.30			1392.00
Weight of Tube (g)		447.18			472.05
Weight of Wet Sample (g)		965.12			919.95
Length 1 (in)		5.932			6.292
Length 2 (in)		5.926			6.303
Length 3 (in)		5.952			6.275
Top Diameter (in)		2.886			2.884
Middle Diameter (in)		2.885			2.891
Bottom Diameter (in)		2.888			2.887
Sample Volume (cm^3)		636.47			674.70
Moisture Content (%)		70.09			102.27
Unit Wet Weight (g/cm^3)		1.52			1.36
Unit Wet Weight (pcf)		94.62			85.08
Unit Dry Weight (g/cm^3)		**0.89**			**0.67**
Unit Dry Weight (pcf)		**55.6**			**42.1**

SOIL PROFILE AND SAMPLING

DEPTH ( )	ELEV ( )	SECTION No.	SOIL PROFILE	SOIL DESCRIPTION AND REMARKS	TEST PERFORMED
		6			NO TEST
15.3		5		GRAY ELASTIC SILT WITH SAND	SIEVE, MC, LOI HYDRO,UNIT WGT. ORGANIC LIMITS SPECIFIC GRAVITY CONSOLIDATION
15.8		4			NO TEST
16.3		3			NO TEST
16.8		2		GRAY ELASTIC SILT	SIEVE, MC ORGANIC LIMITS LOI UNIT WEIGHT
17.3		1			MC

***Note**: When full recovery is not achieved, the elevation can not be accurately defined.*
Indicate each cut of the tube with an arrow.
Indicate dividing line between soil types with a solid line.
Indicate wax by cross-hatching. Indicate soil types by standard symbols.

Tested By TM Date 5/09/19 Checked By KC Date 5/23/19

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SHELBY TUBE UNIT WEIGHT

ASTM D7263-09

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth Pushed (ft):	19.0-21.3
Project No.:	2019-264-001	Shelby Tube No.:	ST-1A & ST-1B
Lab ID:	2019-264-001-004 & 005	Recovery (ft):	2.3

MOISTURE CONTENT

Section Number	**1**	**2**	**3**	**4**	**5**
Tare Number	3282	1536			1505
Weight of Tare & Wet Sample (g)	95.90	601.24			565.07
Weight of Tare & Dry Sample (g)	59.45	405.94			393.11
Weight of Tare (g)	8.22	149.31			140.23
Moisture Content (%)	71.15	76.10			68.00

UNIT WEIGHT

Weight of Tube & Wet Sample (g)		1392.40	1470.80
Weight of Tube (g)		439.97	459.17
Weight of Wet Sample (g)		952.43	1011.63
Length 1 (in)		5.873	6.099
Length 2 (in)		5.857	6.117
Length 3 (in)		5.861	6.105
Top Diameter (in)		2.886	2.889
Middle Diameter (in)		2.878	2.884
Bottom Diameter (in)		2.887	2.880
Sample Volume (cm^3)		627.44	653.79
Moisture Content (%)		76.10	68.00
Unit Wet Weight (g/cm^3)		1.52	1.55
Unit Wet Weight (pcf)		94.72	96.55
Unit Dry Weight (g/cm^3)		**0.86**	**0.92**
Unit Dry Weight (pcf)		**53.8**	**57.5**

SOIL PROFILE AND SAMPLING

DEPTH ( )	ELEV ( )	SECTION No.	SOIL PROFILE	SOIL DESCRIPTION AND REMARKS	TEST PERFORMED
		6			NO TEST
19.3		5		GRAY SANDY ELASTIC SILT	SIEVE, MC, LOI HYDRO,UNIT WGT. ORGANIC LIMITS SPECIFIC GRAVITY CONSOLIDATION
19.8		4			NO TEST
20.3		3			NO TEST
20.8		2		GRAY ELASTIC SILT	SIEVE, MC ORGANIC LIMITS LOI UNIT WEIGHT
21.3		1			MC

***Note**: When full recovery is not achieved, the elevation can not be accurately defined.*
Indicate each cut of the tube with an arrow.
Indicate dividing line between soil types with a solid line.
Indicate wax by cross-hatching. Indicate soil types by standard symbols.

Tested By TM Date 5/10/19 Checked By KC Date 5/23/19

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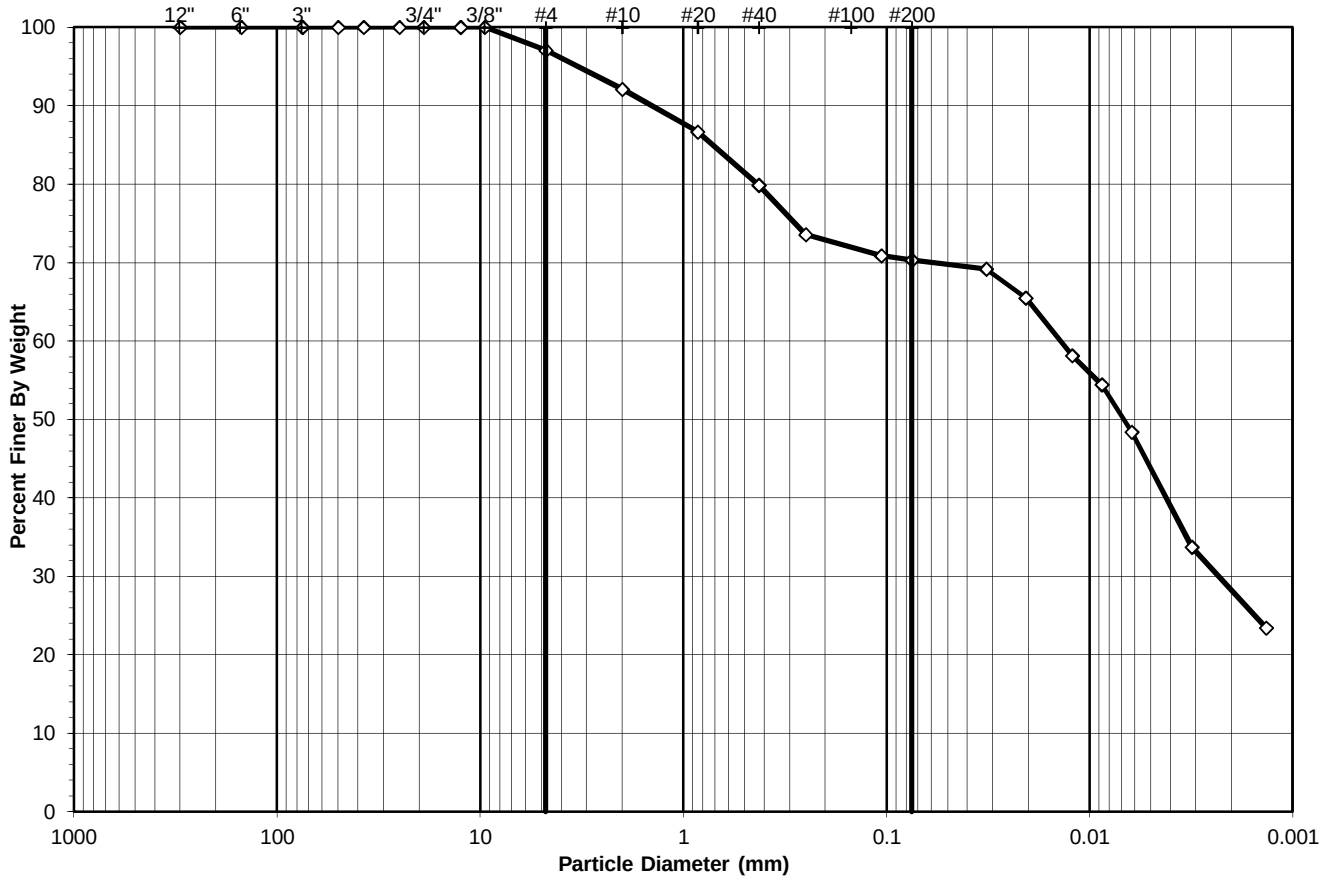
SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Soil Color:	Gray

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



USCS Summary

Sieve Sizes (mm)		Percentage
Greater Than #4	*Gravel*	2.91
#4 To #200	*Sand*	26.76
Finer Than #200	*Silt & Clay*	70.32

USCS Symbol:

MH, TESTED

USCS Classification:

ELASTIC SILT WITH SAND

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

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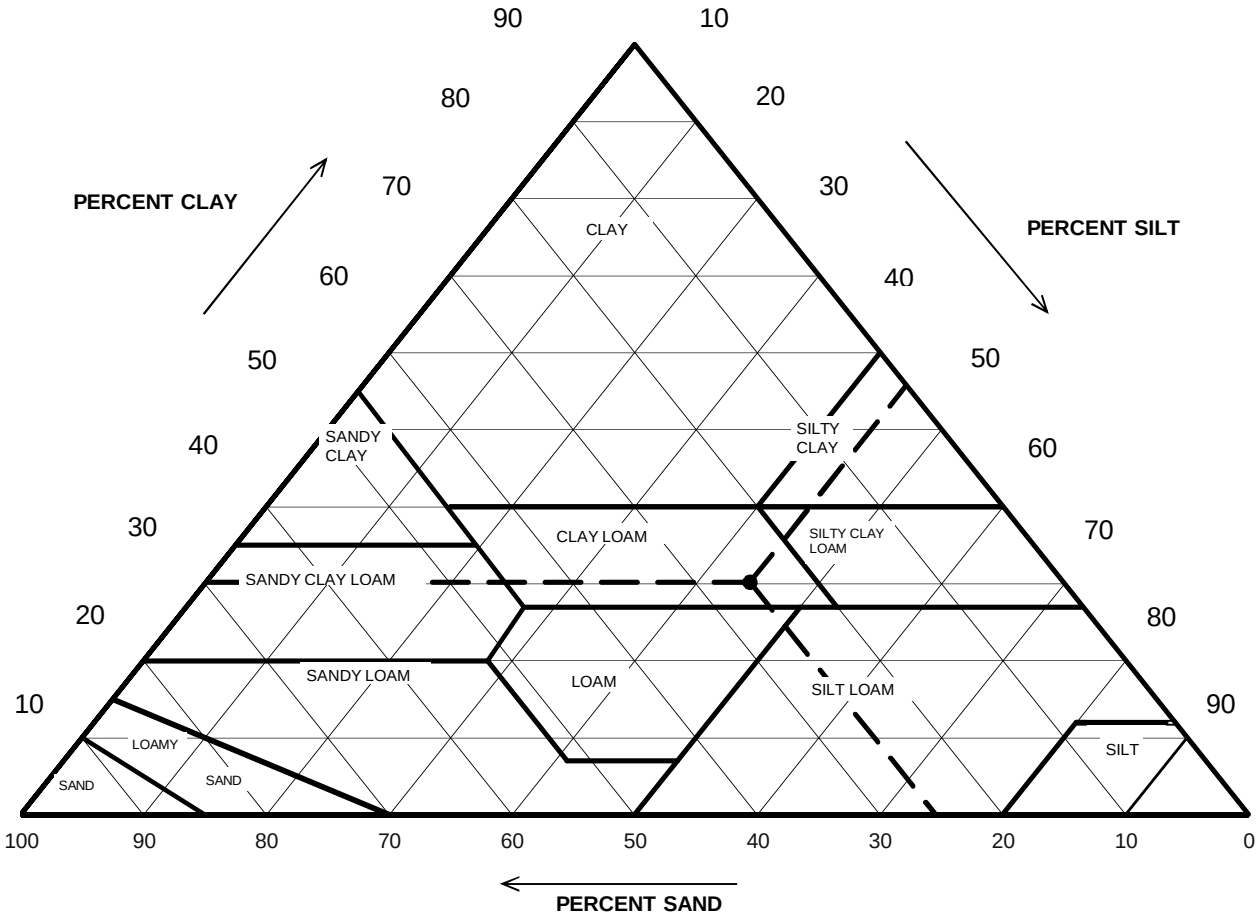
USDA CLASSIFICATION CHART

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Soil Color:	Gray



Particle Size (mm)	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
		Gravel	7.89	**0.00**
2	92.11	*Sand*	23.50	**25.51**
0.05	68.61	*Silt*	40.77	**44.26**
0.002	27.84	*Clay*	27.84	**30.23**

USDA Classification: ***CLAY LOAM***

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

S:Excel\Excel QA\Spreadsheets\SieveHydJ.xls

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Soil Color:	Gray

Moisture Content of Passing 3/4" Material		Moisture Content of Retained 3/4" Material	
Tare No.:	1516	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	409.36	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	274.61	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	142.85	Weight of Tare (g):	NA
Weight of Water (g):	134.75	Weight of Water (g):	NA
Weight of Dry Soil (g):	131.76	Weight of Dry Soil (g):	NA
Moisture Content (%):	**102.3**	**Moisture Content (%):**	**0.0**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	131.76
Dry Weight of - 3/4" Sample (g):	131.8	Weight of Minus #200 Material (g):	92.66
Wet Weight of +3/4" Sample (g):	0.00	Weight of Plus #200 Material (g):	39.10
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	131.8		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25.0	0.00		0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00		0.00	0.00	100.00	**100.00**
1/2"	12.5	0.00		0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00		0.00	0.00	100.00	**100.00**
#4	4.75	3.84		2.91	2.91	97.09	**97.09**
#10	2.00	6.56		4.98	7.89	92.11	**92.11**
#20	0.85	7.17	(**)	5.44	13.33	86.67	**86.67**
#40	0.425	8.95		6.79	20.13	79.87	**79.87**
#60	0.250	8.31		6.31	26.43	73.57	**73.57**
#140	0.106	3.54		2.69	29.12	70.88	**70.88**
#200	0.075	0.73		0.55	29.68	70.32	**70.32**
Pan	-	92.66		70.32	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Sample*

Tested By HL Date 5/14/19 Checked By KC Date 5/16/19

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Soil Color:	Gray

Elapsed Time		R Measured	Temp.	Composite Correction	R Corrected	N	K Factor	Diameter	N'
(min)			(°C)			(%)		(mm)	(%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		35.0	21.6	6.84	28.2	98.4	0.01404	0.0323	**69.2**
5		33.5	21.6	6.84	26.7	93.1	0.01404	0.0206	**65.5**
15		30.5	21.6	6.84	23.7	82.7	0.01404	0.0122	**58.1**
30		29.0	21.6	6.84	22.2	77.4	0.01404	0.0087	**54.4**
61		26.5	21.7	6.80	19.7	68.8	0.01402	0.0062	**48.4**
250		20.0	23.3	6.27	13.7	47.9	0.01376	0.0031	**33.7**
1440		16.0	22.7	6.47	9.5	33.3	0.01386	0.0014	**23.4**

Soil Specimen Data		**Other Corrections**	
Tare No.:	1463		
Wt. of Tare & Dry Material (g):	134.11	a - Factor:	1.03
Weight of Tare (g):	99.62		
Weight of Deflocculant (g):	5.0	Percent Finer than # 200:	70.32
Weight of Dry Material (g):	29.49		
		Specific Gravity:	2.5 Measured

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 5/14/19 Checked By KC Date 5/16/19

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

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Atterberg Limits with Organic Content Test*

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Soil Description:	GRAY ELASTIC SILT

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

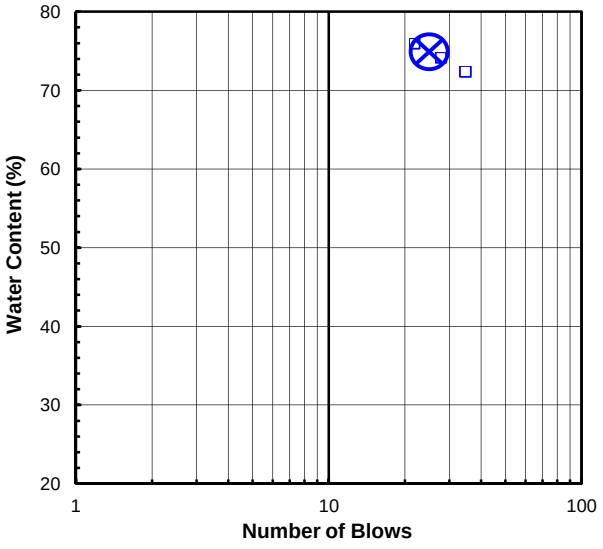
As Received Moisture Content ASTM D2216-10		Liquid Limit Standard Preparation			Liquid Limit *Dried at 110° Prior to Testing		
		1	2	3	4	5	6
Tare Number	1516	613	617	623	111	619	621
Wt. of Tare & Wet Sample (g)	409.36	40.07	39.93	40.60	40.84	40.36	40.18
Wt. of Tare & Dry Sample (g)	274.61	31.52	31.25	31.66	33.16	32.88	32.71
Wt. of Tare (g)	142.85	19.69	19.53	19.87	19.24	19.66	19.50
Wt. of Water (g)	134.8	8.6	8.7	8.9	7.7	7.5	7.5
Wt. of Dry Sample (g)	131.8	11.8	11.7	11.8	13.9	13.2	13.2
Was As Received MC Preserved:	Yes						
Moisture Content (%)	**102.3**	**72.3**	**74.1**	**75.8**	**55.2**	**56.6**	**56.5**
Number of Blows		**35**	**28**	**22**	**33**	**26**	**22**

Plastic Limit Test	1	2	Range
Tare Number	315	611	
Wt. of Tare & Wet Sample (g)	24.56	25.04	
Wt. of Tare & Dry Sample (g)	22.92	23.40	
Wt. of Tare (g)	18.59	19.02	
Wt. of Water (g)	1.6	1.6	
Wt. of Dry Sample (g)	4.3	4.4	
Moisture Content (%)	**37.9**	**37.4**	**0.4**

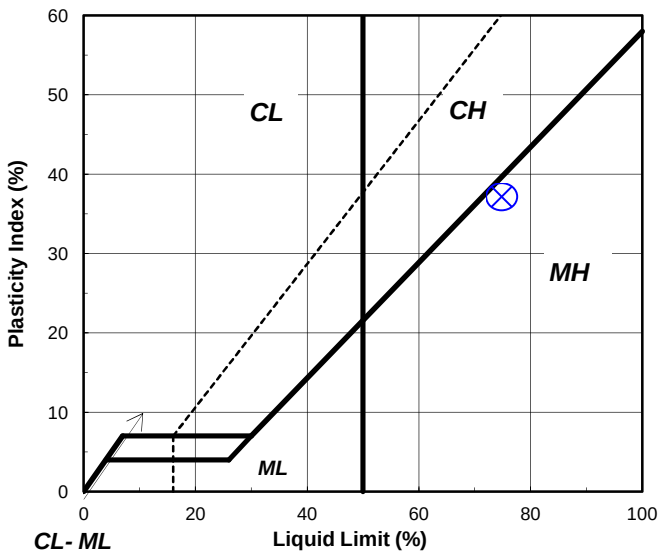
Note: The acceptable range of the two Moisture contents is ± 1.4

Test Results	Standard Prep	*Dried @ 110°
Liquid Limit (%)	**75**	**56**
Plastic Limit (%)	**38**	**N/A**
Plasticity Index (%)	**37**	**N/A**
USCS Symbol	**MH**	**OH**

Flow Curve



Plasticity Chart



Tested By JP *Date* 5/14/19 *Checked By* KC *Date* 5/16/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-001

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	001
Boring No.:	KB19-01
Depth (ft):	15.2-15.7
Sample No.:	ST-1A
Tare Number	DD
Weight of Tare & Wet Sample (g)	212.24
Weight of Tare & Dry Sample (g)	166.48
Weight of Tare (g)	126.15
Weight of Water (g)	45.76
Weight of Dry Sample (g)	40.33
Moisture Content	**113.5%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	164.50
Weight of Volatiles (g)	1.98
Weight of Ash (g)	38.35
Ash Content (%)	**95.1%**
Organic Matter (%)	**4.9%**

Tested By SG *Date* 5/13/19 *Checked By* BRB *Date* 5/14/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

\\GEOSERVER\Data Drive\2019 GEOTECHNICAL PROJECTS\Key Environmental, Inc\2019-264-001 North Landfarm 19819\[2019-264-001-001 LOI D2974.xls]Sheet1

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SPECIFIC GRAVITY

ASTM D 854-14

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Gray Clay with Sand/Gravel/ Organics

(MInus No.4 sieve material,oven dried)

Replicate Number	**1**	**2**
Pycnometer ID:	G 1848	G 1917
Weight of Pycnometer & Soil & Water (g):	717.74	714.04
Temperature (^{o}C):	23.3	23.4
Weight of Pycnometer & Water (g):	686.65	684.18
Tare Number:	957	2337
Weight of Tare & Dry Soil (g):	150.55	145.47
Weight of Tare (g):	99.47	94.86
Weight of Dry Soil (g):	51.08	50.61
Specific Gravity of Soil @ Measured Temperature:	2.556	2.439
Specific Gravity of Water @ Measured Temperature:	0.99747	0.99745
Conversion Factor for Measured Temperature:	0.99926	0.99924
Specific Gravity @ 20^{o} Celsius:	2.557	2.441

Average Specific Gravity @ 20^{o} Celsius	2.50

Tested By TO *Date* 5/14/19 *Checked By* BRB *Date* 5/15/19

DCN: CT-S5 Date: 3/26/18 Revision: 21

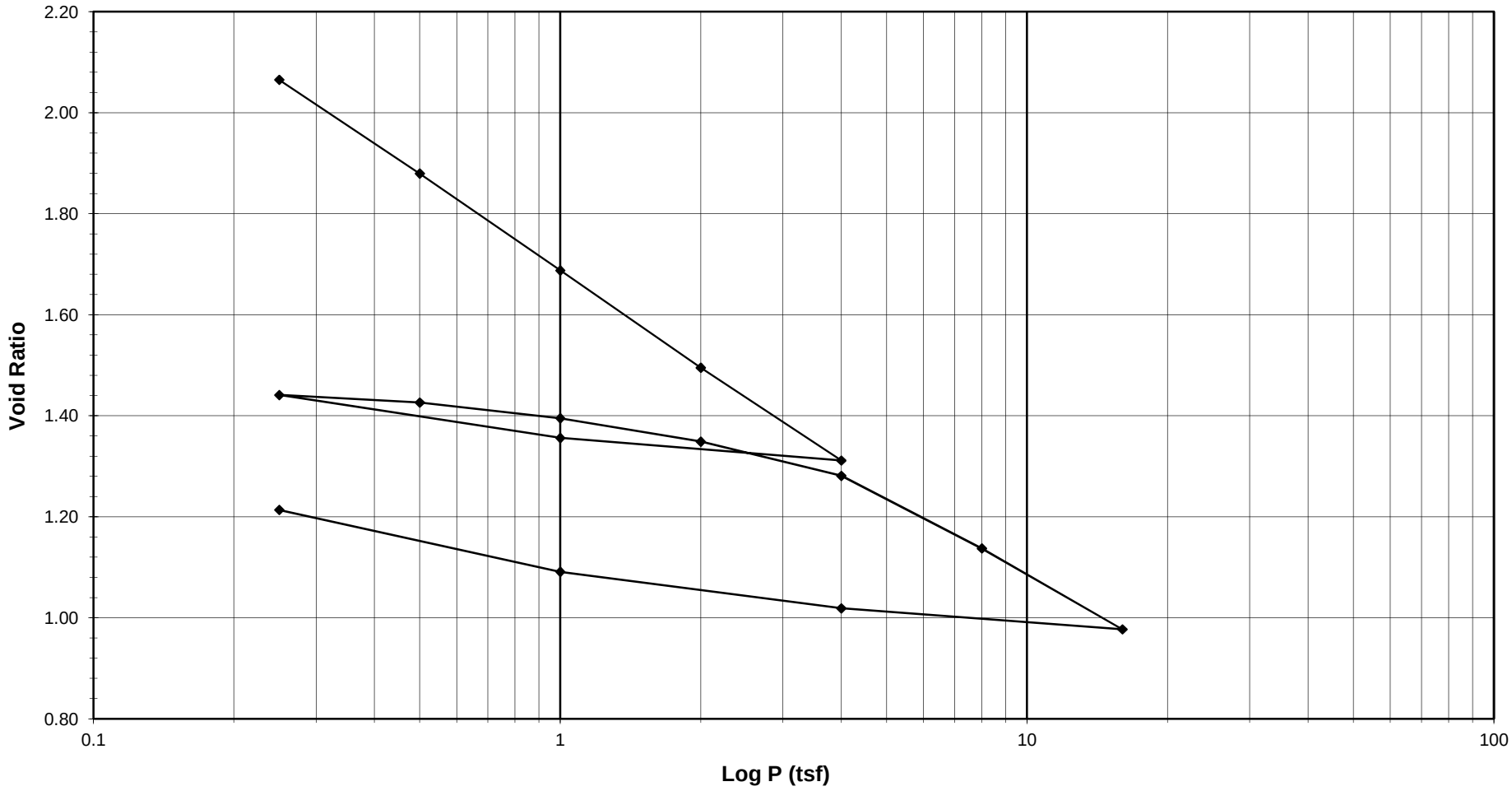
S:\Excel\Excel QA\Spreadsheets\Specific Gravity.xls

ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED



Tested By TM *Date* 5/10/19 *Approved By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED
Consolidometer No. G1418
1 Division = 0.0001 (in.)

Sample Properties	**Initial**	**Final**
Water Content		
Tare Number	2900	3374
Wt. of Tare & WS (g)	78.85	80.15
Wt. of Tare & DS (g)	39.26	58.87
Wt. of Water (g)	39.59	21.28
Wt. of Tare (g)	8.15	8.33
Wt. of DS (g)	31.11	50.54
Water Content (%)	127.26	42.11
Sample Parameters		
Sample Diameter (in)	2.5	2.5
Sample Height (in)	1.0000	0.5318
Sample Volume (cm^3)	80.44	42.77
Wt. of Wet Sample + Ring (g)	323.73	282.60
Wt. of Ring (g)	213.95	213.95
Wt. of Wet Sample (g)	109.78	68.65
Wet Density (pcf)	85.16	100.14
Wet Density (g/cm^3)	1.36	1.60
Water Content (%)	127.26	42.11
Wt. of Dry Sample (g)	48.31	48.31
Dry Density (pcf)	37.47	70.47
Dry Density (g/cm^3)	0.60	1.13
Void Ratio	3.1630	1.2137
Saturation (%)	100.58	86.73
Specific Gravity	2.50	*Measured*

Test Data Summary

Applied Pressure (tsf)	**Final Dial Reading** (div)	**Machine Deflection** (div)	**Corrected Reading** (div)	**Height of Sample** (mm)	**Volume** (cm^3)	**Dry Density** (g/cm^3)	**Void Ratio**
Seating	0	0	0	25.400	80.440	0.60053	**3.16301**
0.25	2646.5	9.5	2637.0	18.702	59.228	0.81560	**2.06522**
0.5	3102.3	19.4	3082.9	17.570	55.641	0.86817	**1.87961**
1	3574.4	30.7	3543.7	16.399	51.935	0.93014	**1.68778**
2	4051.0	44.6	4006.4	15.224	48.212	1.00195	**1.49512**
4	4520.3	72.8	4447.5	14.103	44.664	1.08155	**1.31151**
1	4378.8	38.5	4340.3	14.376	45.527	1.06106	**1.35614**
0.25	4156.4	20.2	4136.2	14.894	47.169	1.02412	**1.44112**
0.5	4194.9	23.0	4171.9	14.803	46.881	1.03039	**1.42626**
1	4278.6	31.9	4246.7	14.614	46.280	1.04379	**1.39512**
2	4402.9	45.3	4357.7	14.332	45.387	1.06432	**1.34891**
4	4593.7	73.2	4520.5	13.918	44.077	1.09594	**1.28114**
8	4972.1	106.4	4865.7	13.041	41.300	1.16964	**1.13741**
16	5394.3	143.8	5250.5	12.064	38.205	1.26441	**0.97720**
4	5234.0	83.5	5150.5	12.318	39.010	1.23832	**1.01887**
1	5019.1	42.0	4977.1	12.758	40.404	1.19559	**1.09102**
0.25	4707.0	24.5	4682.5	13.506	42.774	1.12934	**1.21368**

Tested By *TM* *Date* *5/10/19* *Input Checked By* *NJM* *Date* *5/21/19*

DCN: CT-24E Date: 8/15/12 Revision: 2

GeoJac-32tsf.xlt

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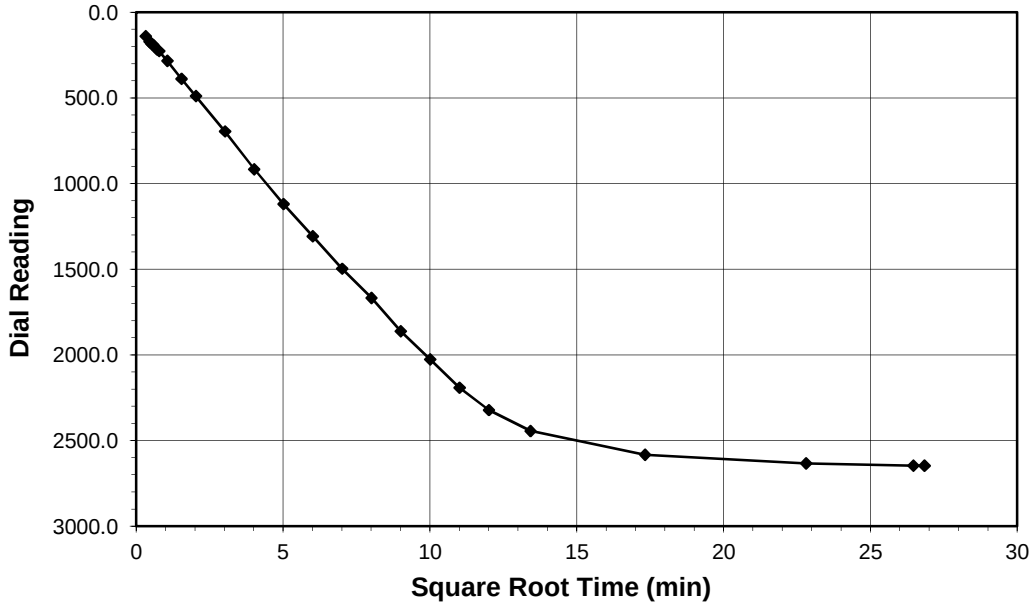
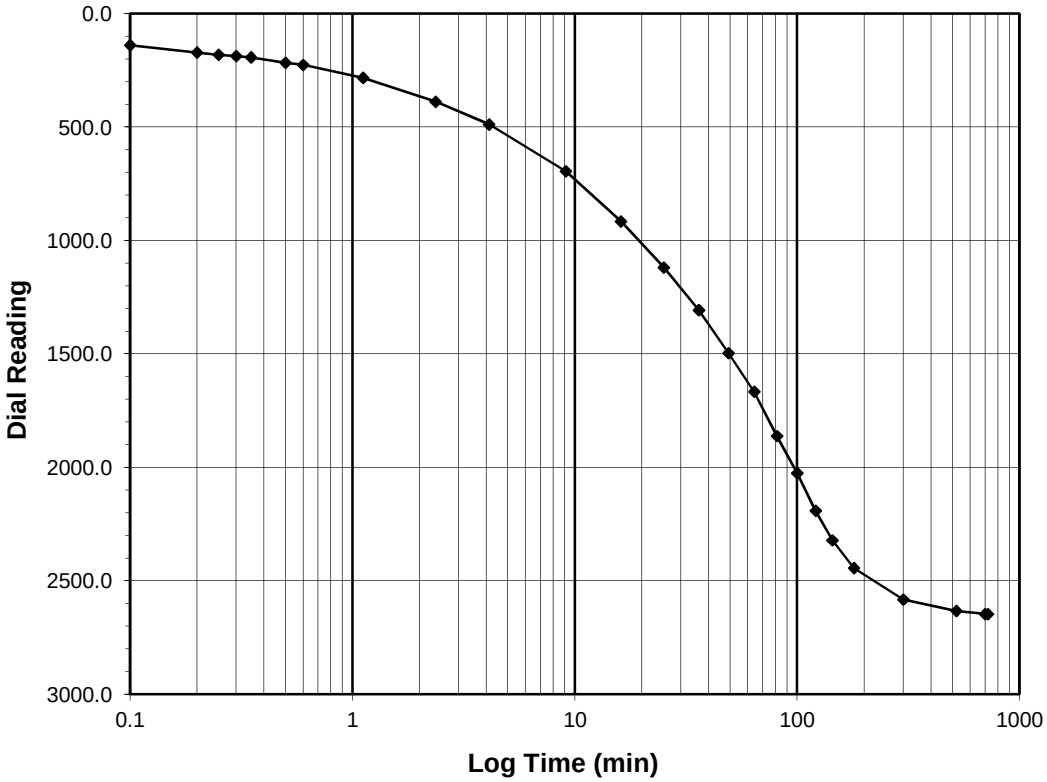
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0 - 0.25**
Final Reading	**(div)**	**2646.5**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/10/19
Start Time		7:21:47

Elapsed Time (min)	Dial Reading (div)
Initial	**0.0**
0.10	139.2
0.20	171.5
0.25	181.6
0.30	187.3
0.35	193.0
0.50	216.8
0.60	226.0
1.12	283.3
2.37	388.4
4.12	488.7
9.12	694.9
16.12	915.9
25.12	1119.0
36.12	1307.3
49.12	1496.5
64.12	1666.9
81.12	1861.8
100.12	2025.7
121.12	2191.3
144.12	2321.6
180.13	2444.0
300.13	2582.8
520.13	2633.0
700.13	2646.5
720.28	2646.5

Tested By TM *Date* 5/10/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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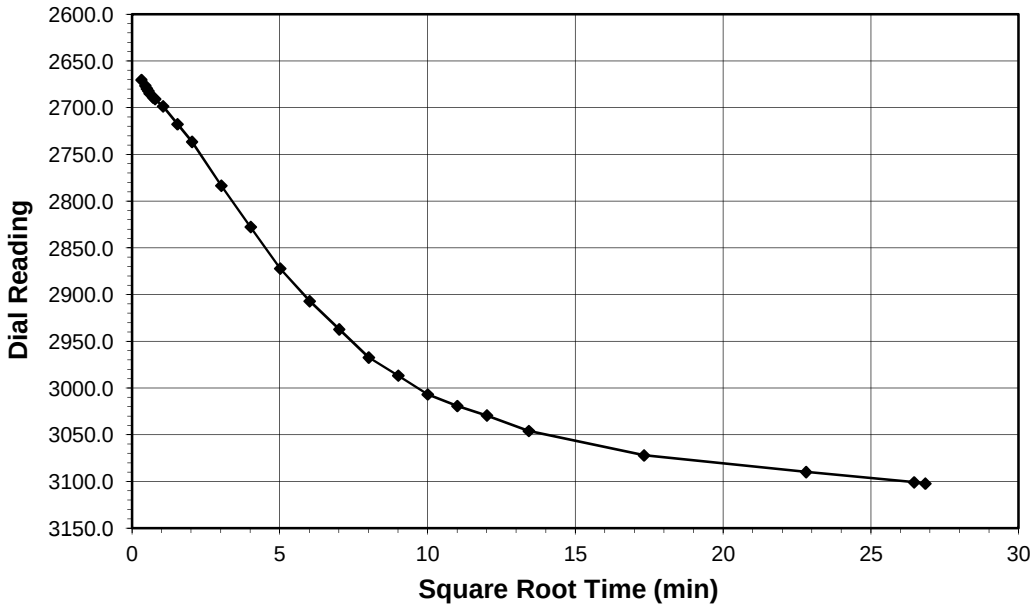
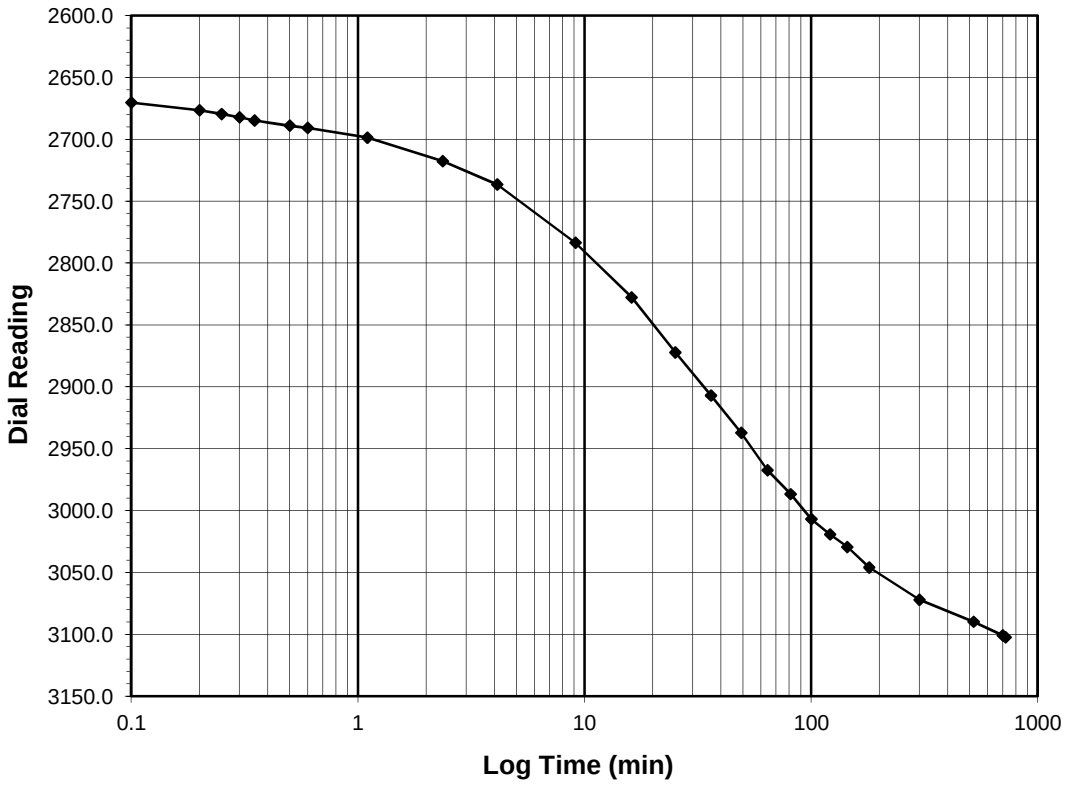
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.25 - 0.5**
Final Reading	**(div)**	**3102.3**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/10/19
Start Time		19:22:04

Elapsed Time (min)	Dial Reading (div)
Initial	**2646.5**
0.10	2670.3
0.20	2676.4
0.25	2679.4
0.30	2682.1
0.35	2684.8
0.50	2688.9
0.60	2690.7
1.10	2698.6
2.37	2717.6
4.12	2736.4
9.12	2783.5
16.12	2827.6
25.12	2872.1
36.12	2907.0
49.12	2937.1
64.12	2967.3
81.12	2986.6
100.12	3006.8
121.12	3019.2
144.13	3029.3
180.13	3045.9
300.13	3072.0
520.13	3089.8
700.13	3100.8
720.38	3102.3

Tested By TM *Date* 5/10/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2

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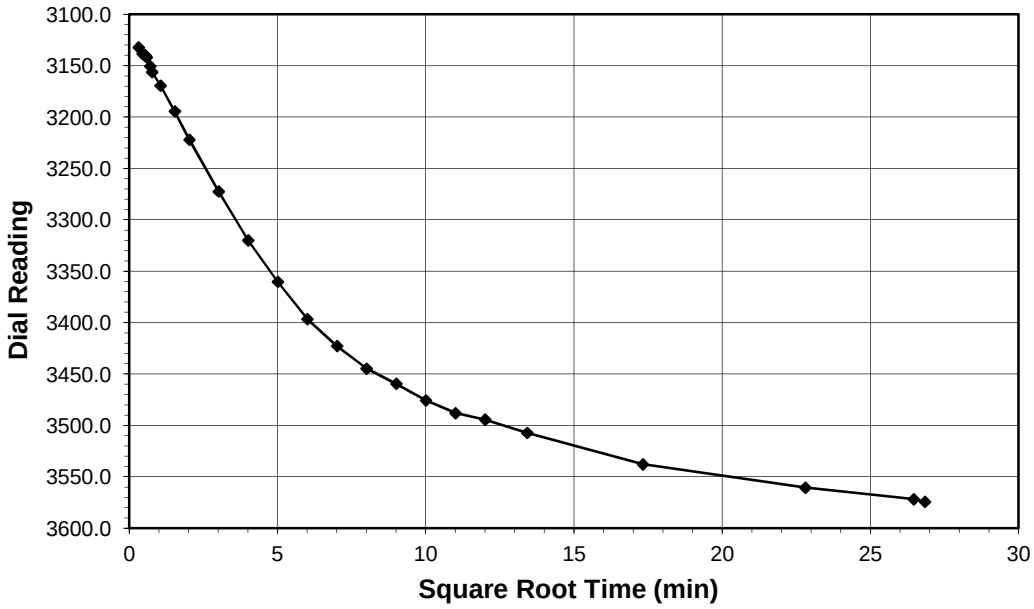
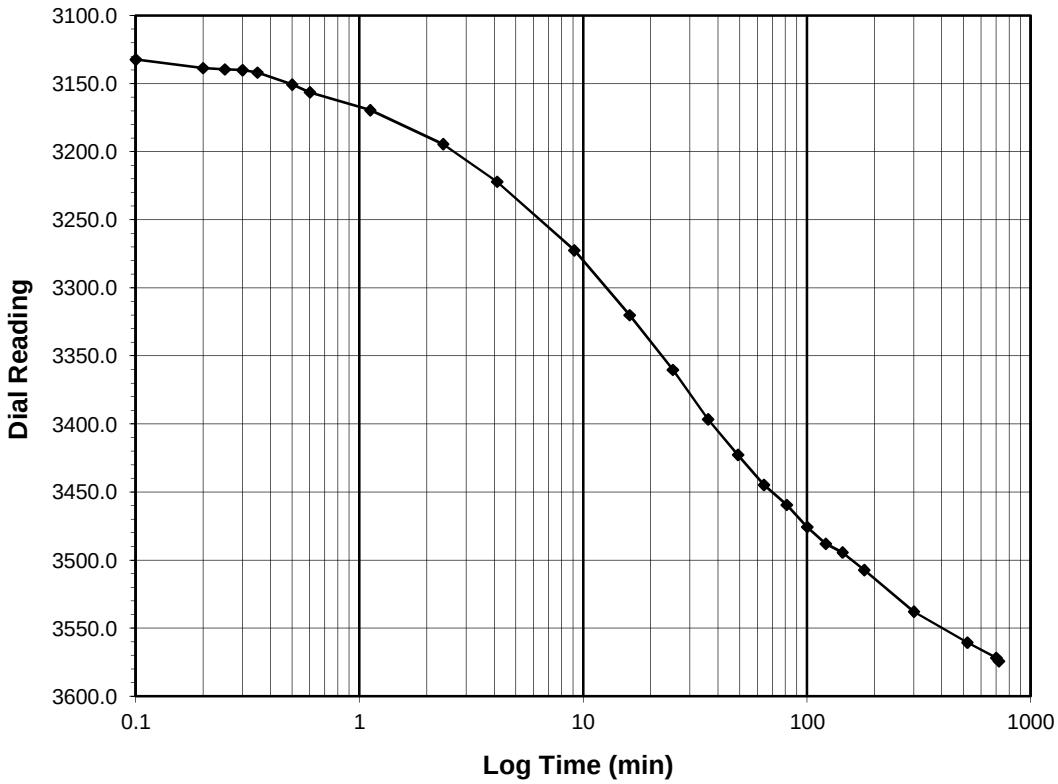
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.5 - 1**
Final Reading	**(div)**	**3574.4**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/11/19
Start Time		7:22:27

Elapsed Time (min)	Dial Reading (div)
Initial	**3102.3**
0.10	3132.3
0.20	3138.6
0.25	3139.5
0.30	3140.0
0.35	3141.9
0.50	3150.7
0.60	3156.3
1.12	3169.4
2.37	3194.4
4.12	3222.0
9.12	3272.4
16.12	3320.0
25.12	3360.2
36.12	3396.6
49.12	3422.7
64.12	3444.7
81.12	3459.5
100.12	3475.6
121.12	3488.0
144.12	3494.4
180.12	3507.2
300.12	3537.8
520.12	3560.6
700.12	3571.8
720.25	3574.4

Tested By *TM* *Date* *5/11/19* *Checked By* *NJM* *Date* *5/21/19*

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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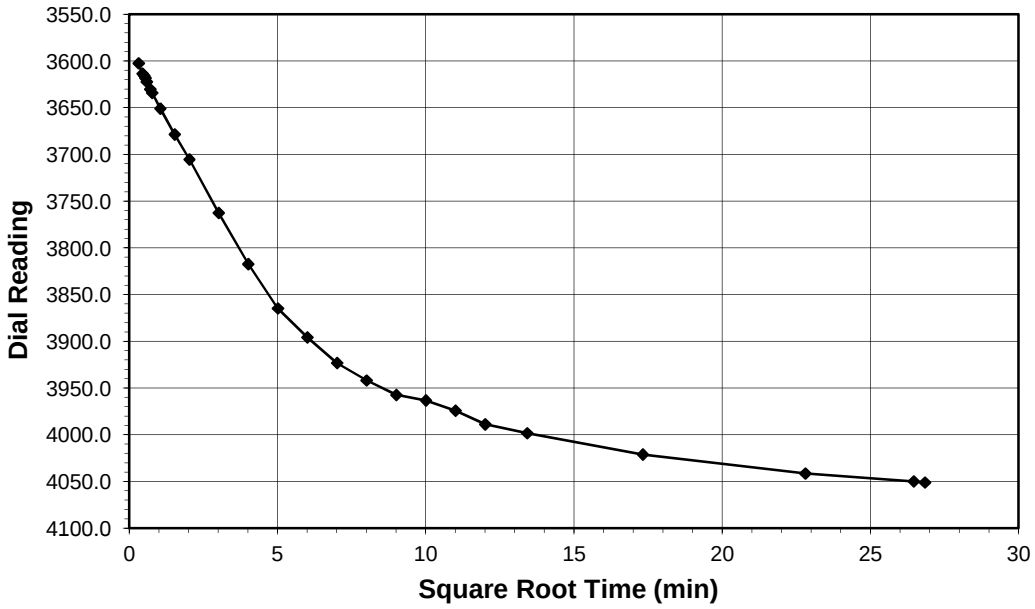
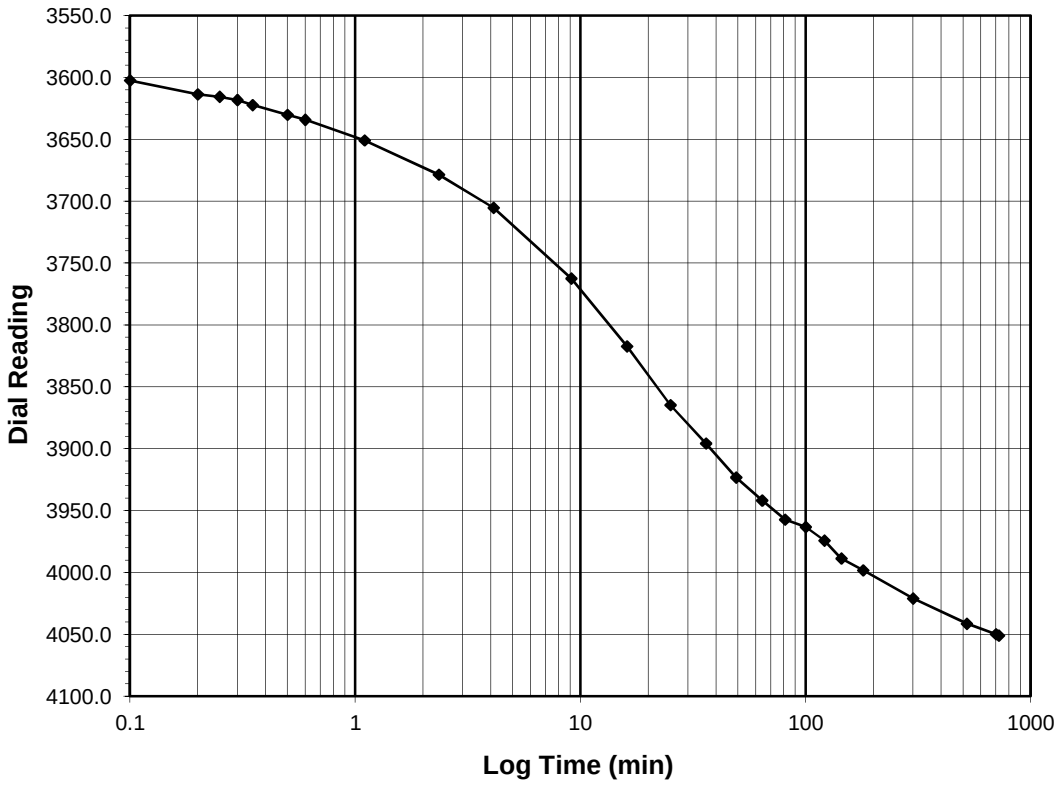
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 2**
Final Reading	**(div)**	**4051.0**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/11/19
Start Time		19:22:42

Elapsed Time (min)	Dial Reading (div)
Initial	**3574.4**
0.10	3602.4
0.20	3613.6
0.25	3615.6
0.30	3618.2
0.35	3622.3
0.50	3630.2
0.60	3634.2
1.10	3650.8
2.35	3678.5
4.12	3705.3
9.12	3762.5
16.12	3817.3
25.12	3864.7
36.12	3895.7
49.12	3923.2
64.12	3941.8
81.12	3957.3
100.12	3963.2
121.12	3974.2
144.12	3988.7
180.12	3998.3
300.12	4021.0
520.12	4041.4
700.12	4049.9
720.40	4051.0

Tested By TM *Date* 5/11/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2

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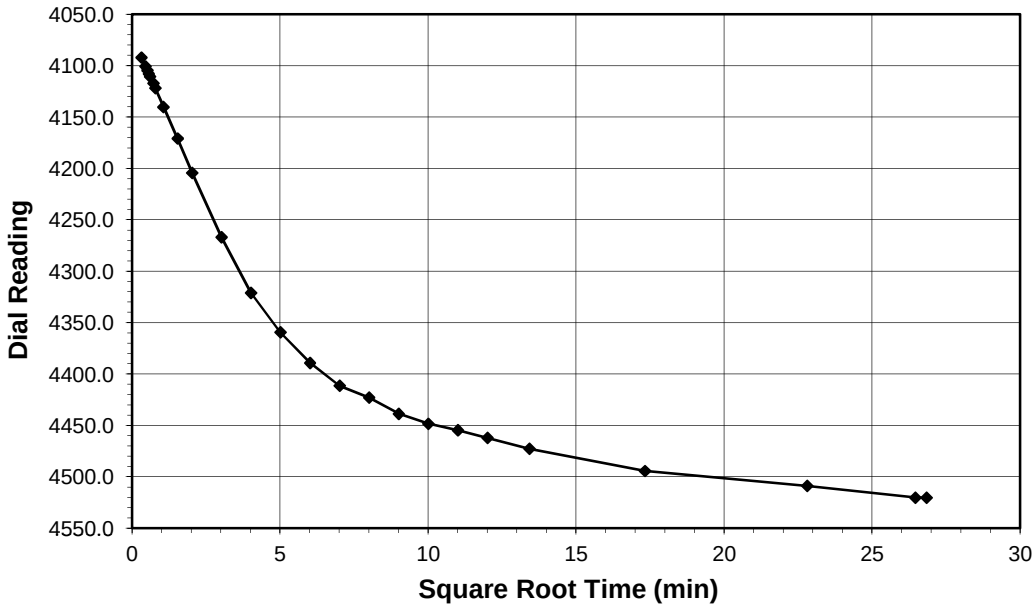
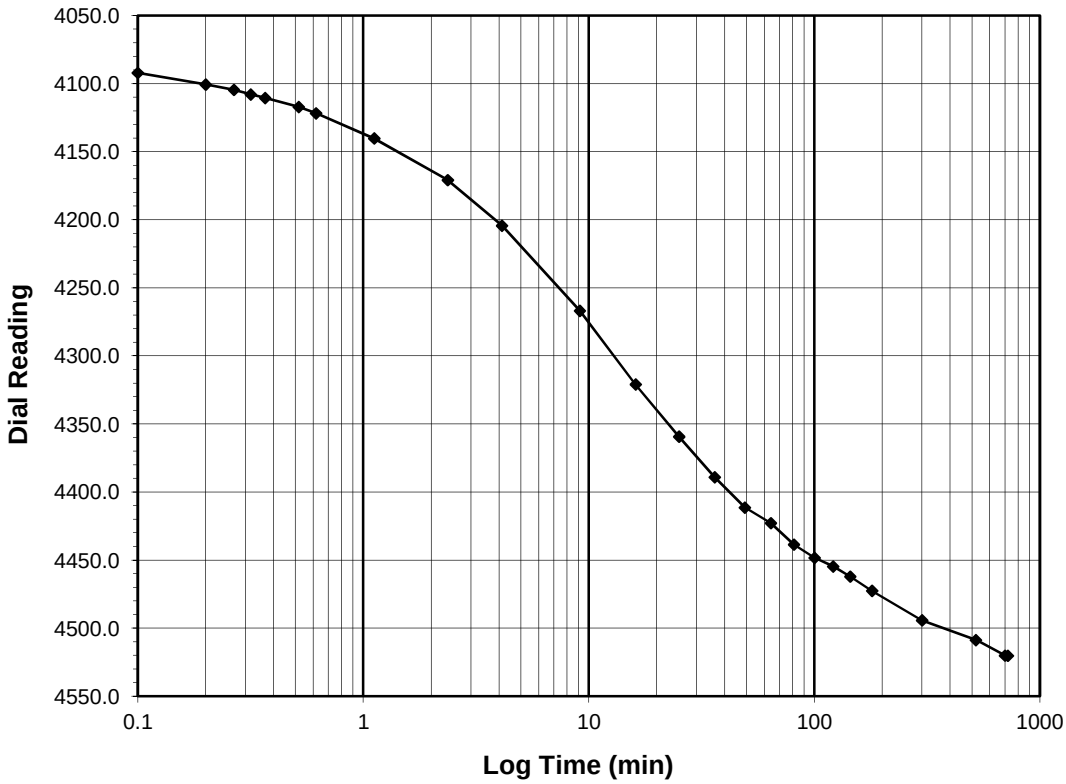
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**2 - 4**
Final Reading	**(div)**	**4520.3**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/12/19
Start Time		7:23:06

Elapsed Time (min)	Dial Reading (div)
Initial	**4051.0**
0.10	4092.1
0.20	4100.6
0.27	4104.5
0.32	4107.9
0.37	4110.5
0.52	4117.1
0.62	4121.8
1.12	4140.2
2.37	4170.8
4.12	4204.3
9.12	4266.8
16.12	4321.0
25.12	4359.3
36.13	4389.1
49.13	4411.4
64.13	4422.8
81.13	4438.6
100.13	4448.3
121.13	4454.7
144.13	4462.1
180.13	4472.6
300.13	4494.3
520.13	4508.7
700.13	4520.2
720.18	4520.3

Tested By *TM* *Date* *5/12/19* *Checked By* *NJM* *Date* *5/21/19*

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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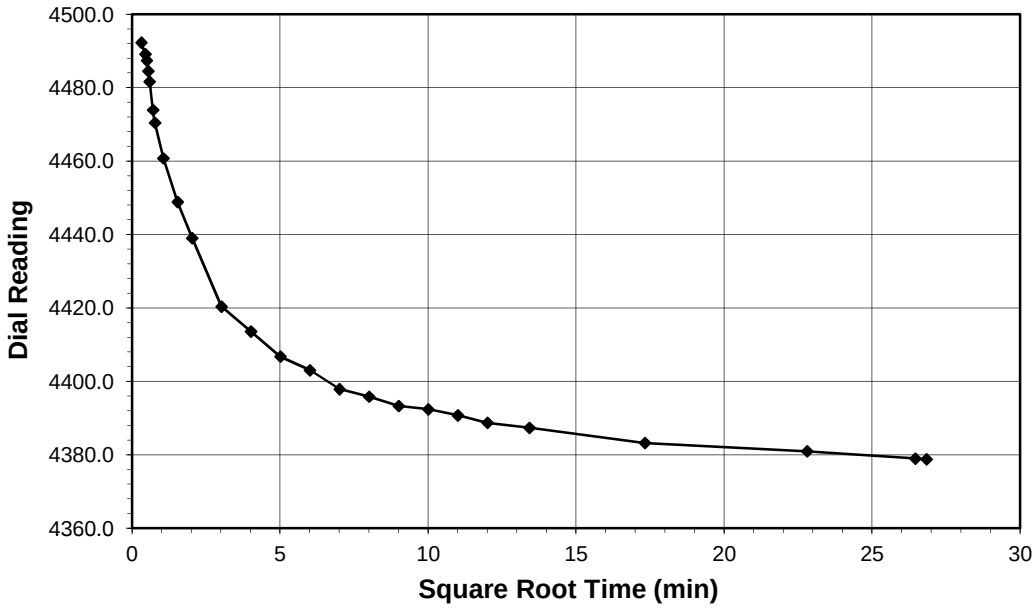
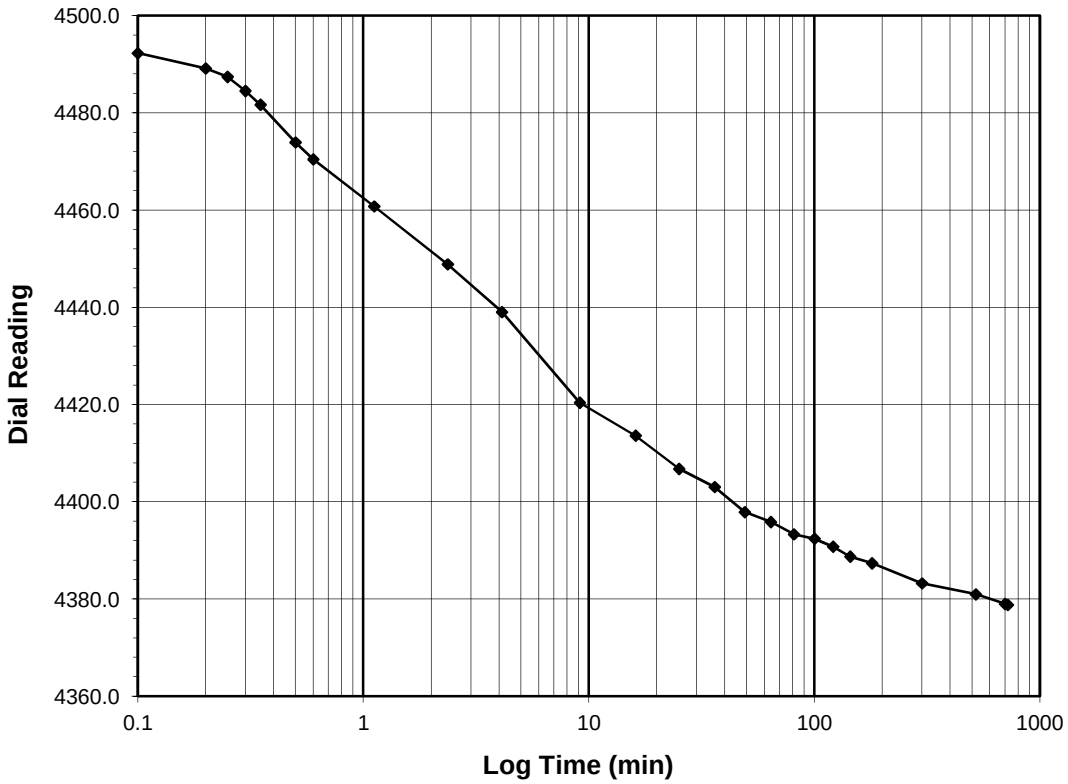
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**4 - 1**
Final Reading	**(div)**	**4378.8**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/12/19
Start Time		19:23:17

Elapsed Time (min)	Dial Reading (div)
Initial	**4520.3**
0.10	4492.3
0.20	4489.1
0.25	4487.4
0.30	4484.5
0.35	4481.7
0.50	4473.9
0.60	4470.4
1.12	4460.8
2.37	4448.8
4.12	4439.0
9.12	4420.4
16.12	4413.6
25.12	4406.8
36.12	4403.0
49.12	4397.9
64.12	4395.8
81.12	4393.3
100.12	4392.4
121.12	4390.8
144.12	4388.7
180.13	4387.4
300.13	4383.2
520.13	4381.0
700.13	4379.0
720.28	4378.8

Tested By *TM* *Date* *5/12/19* *Checked By* *NJM* *Date* *5/21/19*

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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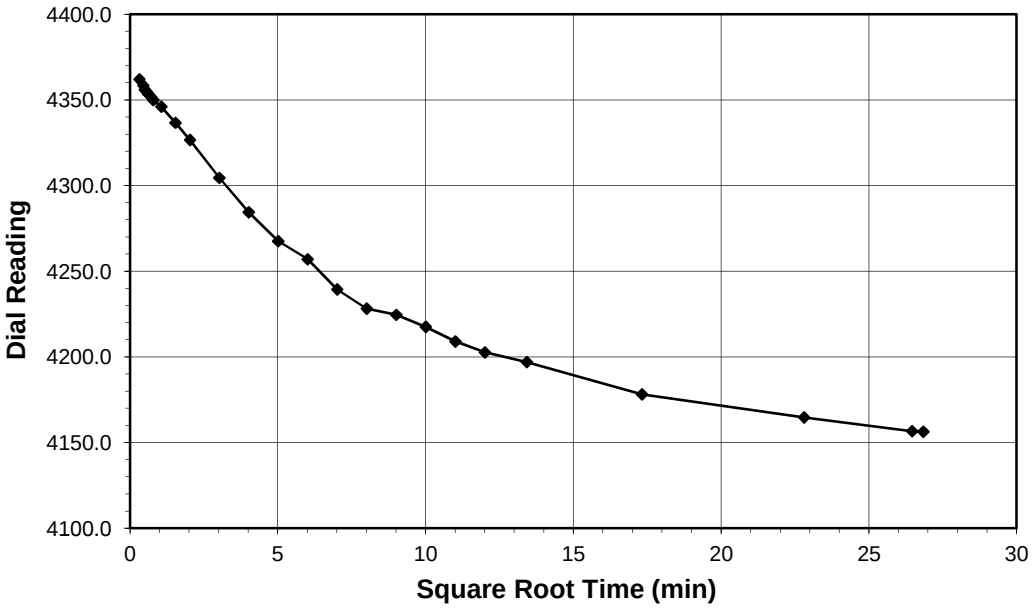
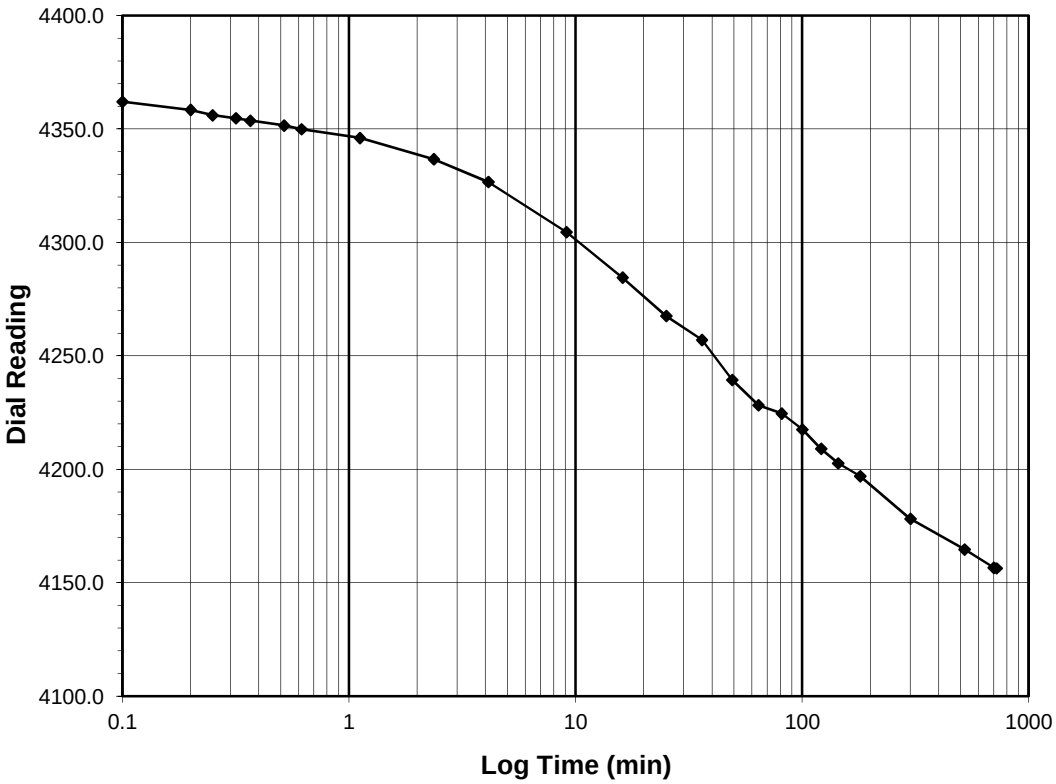
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 0.25**
Final Reading	**(div)**	**4156.4**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/13/19
Start Time		7:23:34

Elapsed Time (min)	Dial Reading (div)
Initial	**4378.8**
0.10	4362.0
0.20	4358.4
0.25	4356.1
0.32	4354.8
0.37	4353.7
0.52	4351.6
0.62	4349.9
1.12	4346.0
2.37	4336.7
4.12	4326.7
9.12	4304.5
16.12	4284.5
25.12	4267.6
36.12	4257.1
49.12	4239.4
64.12	4228.2
81.13	4224.6
100.13	4217.6
121.13	4209.0
144.13	4202.7
180.13	4197.0
300.13	4178.2
520.13	4164.7
700.13	4156.7
720.42	4156.4

Tested By TM *Date* 5/13/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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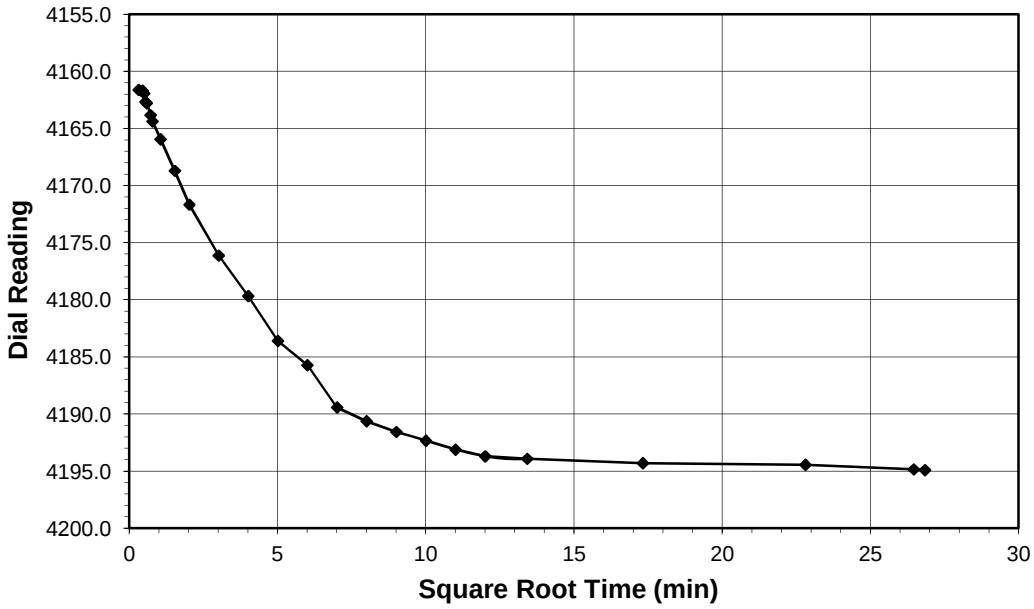
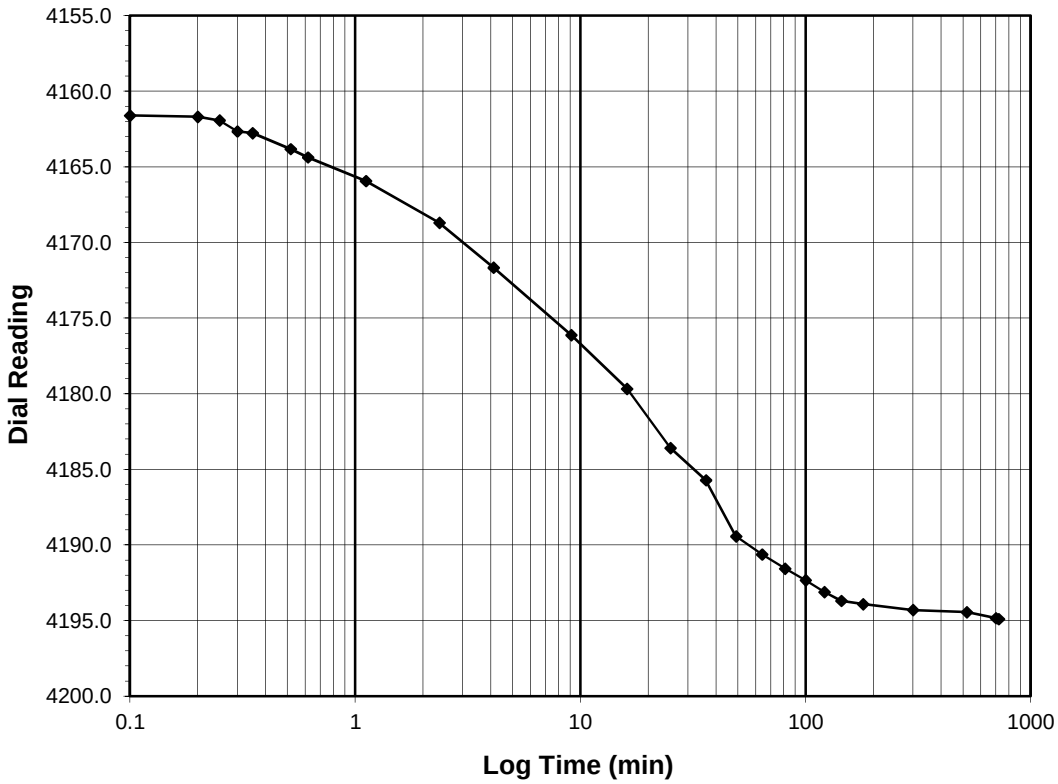
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.25 - 0.5**
Final Reading	**(div)**	**4194.9**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/13/19
Start Time		19:23:59

Elapsed Time (min)	Dial Reading (div)
Initial	**4156.4**
0.10	4161.6
0.20	4161.7
0.25	4161.9
0.30	4162.7
0.35	4162.8
0.52	4163.8
0.62	4164.4
1.12	4165.9
2.37	4168.7
4.12	4171.7
9.12	4176.1
16.12	4179.7
25.12	4183.6
36.12	4185.7
49.12	4189.4
64.12	4190.6
81.13	4191.6
100.13	4192.3
121.13	4193.1
144.13	4193.7
180.13	4193.9
300.13	4194.3
520.13	4194.4
700.13	4194.8
720.38	4194.9

Tested By TM *Date* 5/13/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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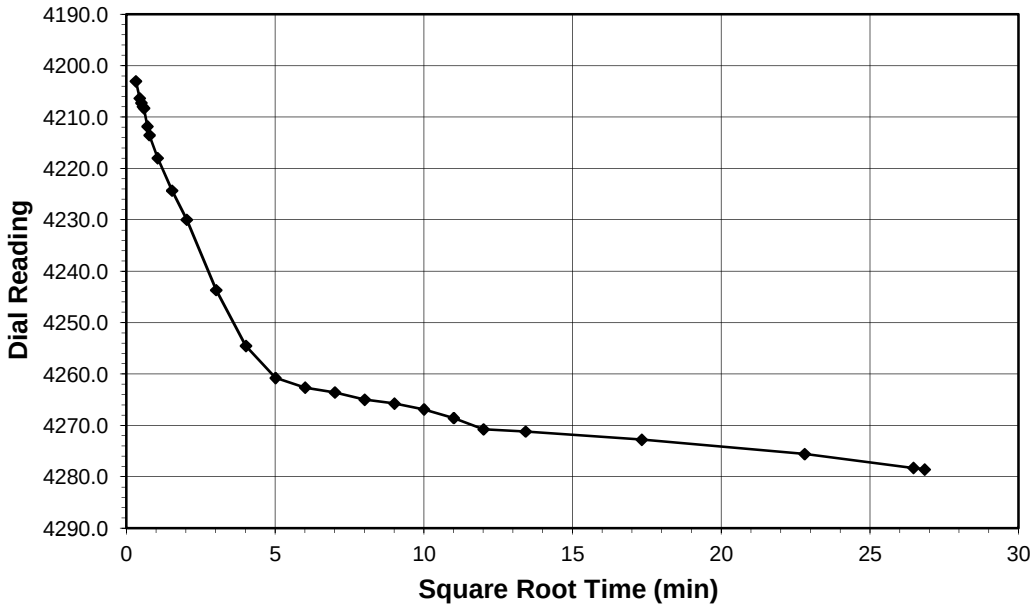
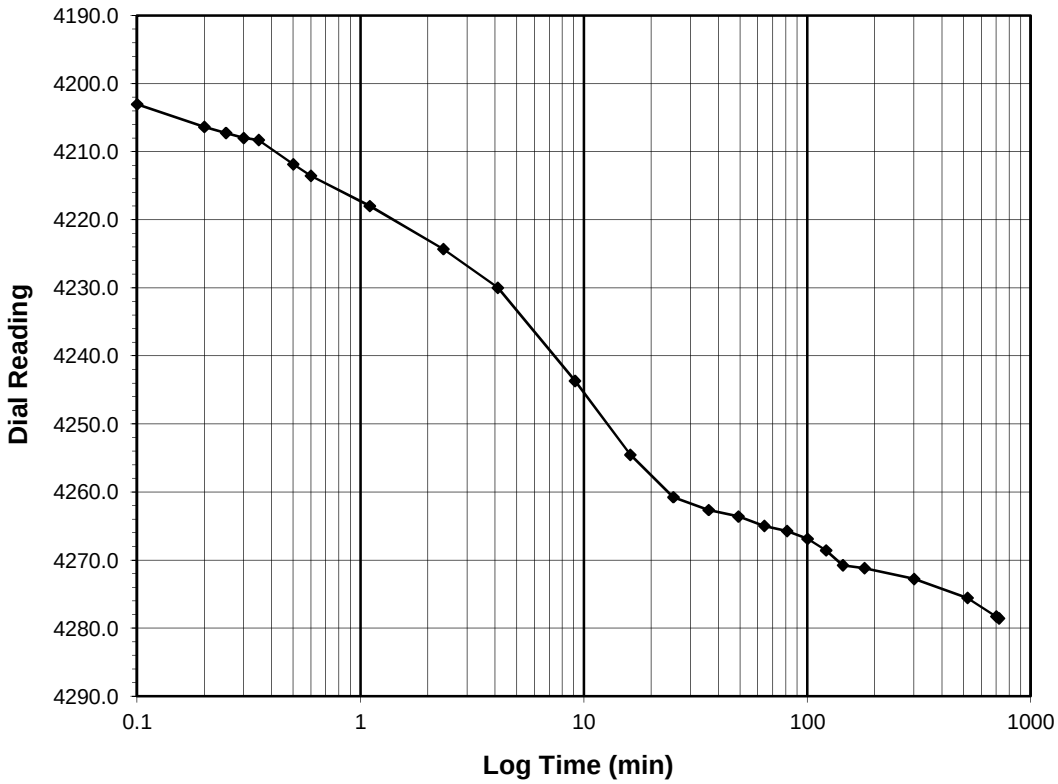
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.5 - 1**
Final Reading	**(div)**	**4278.6**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/14/19
Start Time		7:24:22

Elapsed Time (min)	Dial Reading (div)
Initial	**4194.9**
0.10	4203.0
0.20	4206.4
0.25	4207.2
0.30	4208.0
0.35	4208.3
0.50	4211.8
0.60	4213.5
1.10	4218.0
2.35	4224.3
4.12	4230.0
9.12	4243.7
16.12	4254.5
25.12	4260.8
36.12	4262.6
49.12	4263.6
64.12	4265.0
81.12	4265.7
100.12	4266.9
121.12	4268.6
144.12	4270.8
180.12	4271.2
300.12	4272.8
520.12	4275.6
700.12	4278.3
720.28	4278.6

Tested By TM *Date* 5/14/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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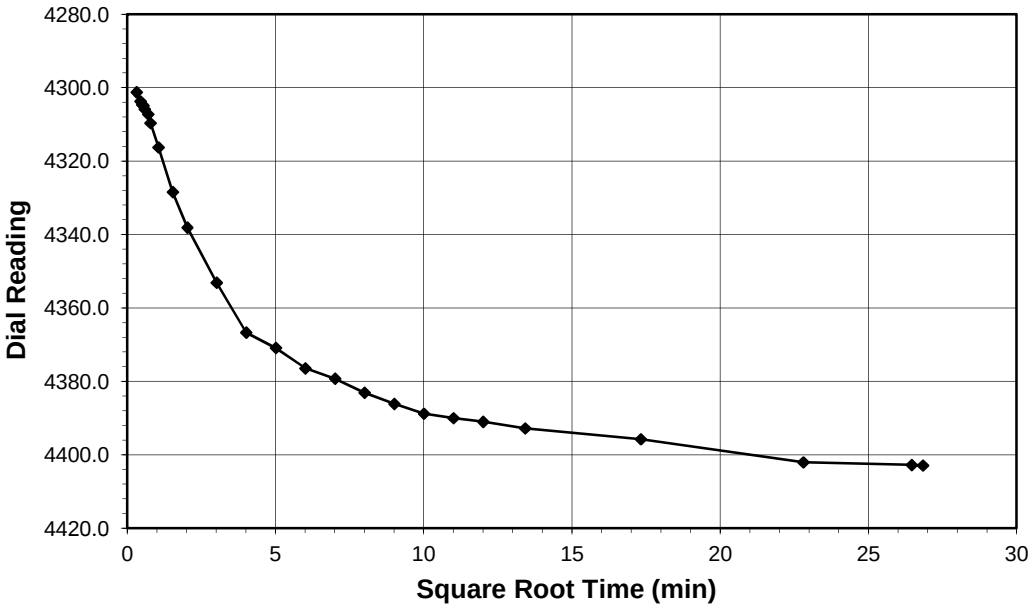
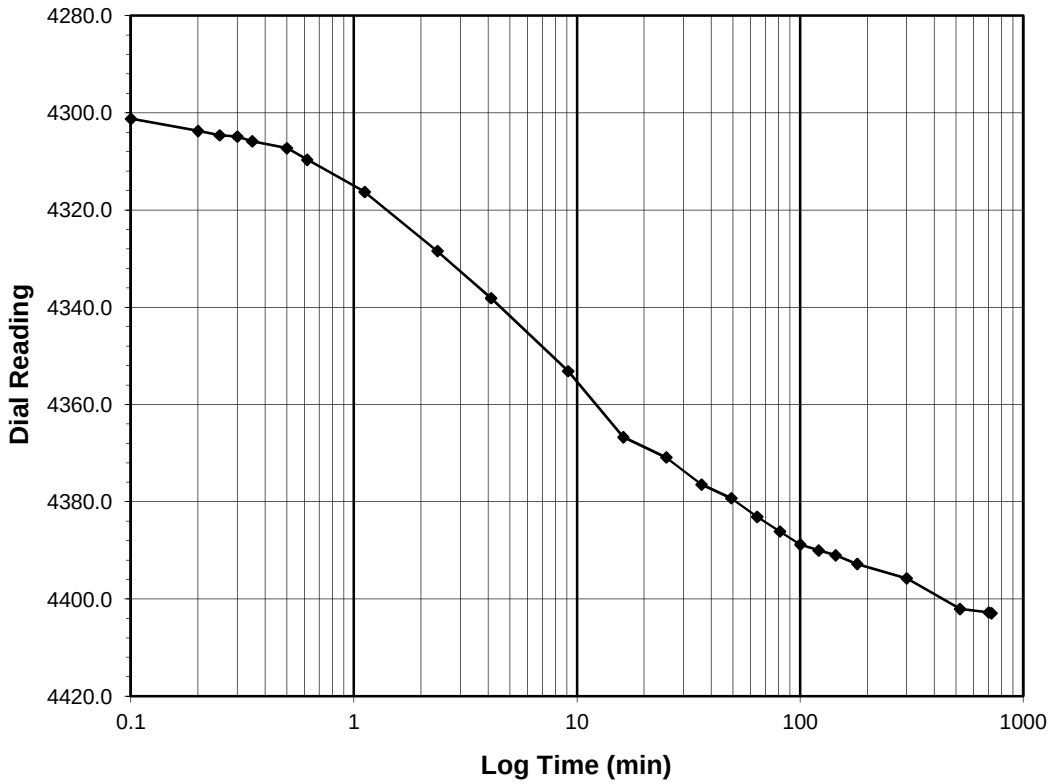
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 2**
Final Reading	**(div)**	**4402.9**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/14/19
Start Time		19:24:39

Elapsed Time (min)	Dial Reading (div)
Initial	**4278.6**
0.10	4301.2
0.20	4303.7
0.25	4304.6
0.30	4304.9
0.35	4305.9
0.50	4307.3
0.62	4309.6
1.12	4316.3
2.37	4328.4
4.12	4338.1
9.12	4353.1
16.12	4366.7
25.12	4370.9
36.12	4376.4
49.12	4379.3
64.12	4383.1
81.12	4386.1
100.12	4388.8
121.12	4390.0
144.12	4391.0
180.12	4392.8
300.12	4395.8
520.12	4402.0
700.12	4402.8
720.32	4402.9

Tested By TM *Date* 5/14/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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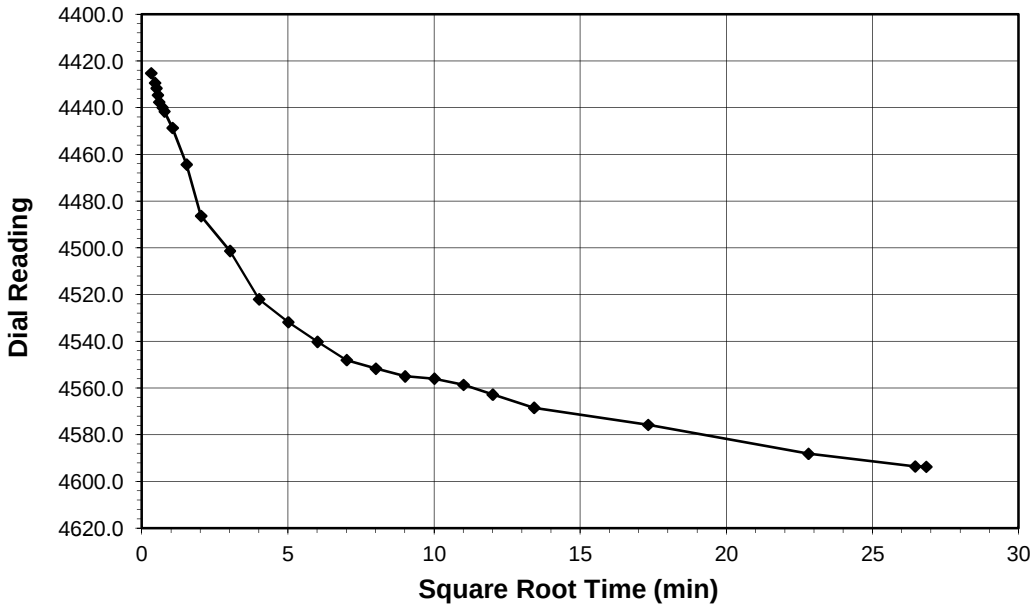
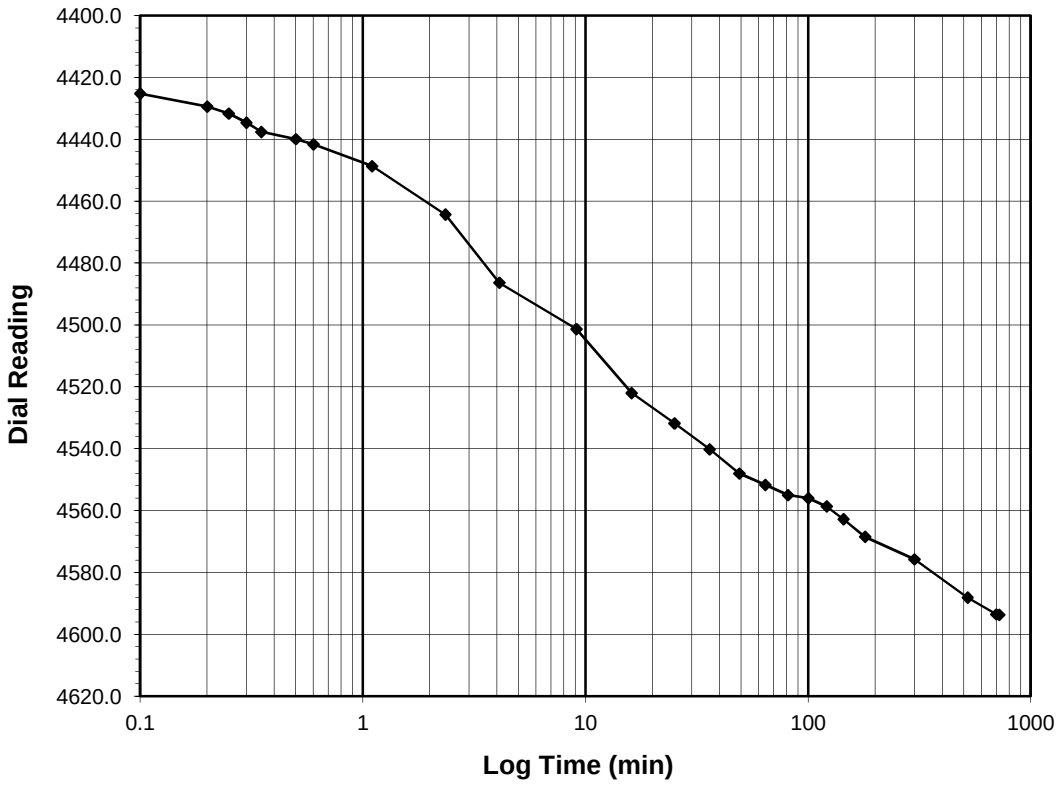
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**2 - 4**
Final Reading	**(div)**	**4593.7**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/15/19
Start Time		7:24:58

Elapsed Time (min)	Dial Reading (div)
Initial	**4402.9**
0.10	4425.2
0.20	4429.4
0.25	4431.7
0.30	4434.6
0.35	4437.6
0.50	4439.9
0.60	4441.6
1.10	4448.6
2.35	4464.3
4.10	4486.3
9.10	4501.3
16.10	4522.0
25.10	4531.8
36.10	4540.2
49.12	4548.0
64.12	4551.7
81.12	4555.0
100.12	4556.0
121.12	4558.6
144.12	4562.8
180.12	4568.5
300.12	4575.7
520.12	4588.1
700.12	4593.5
720.38	4593.7

Tested By TM *Date* 5/15/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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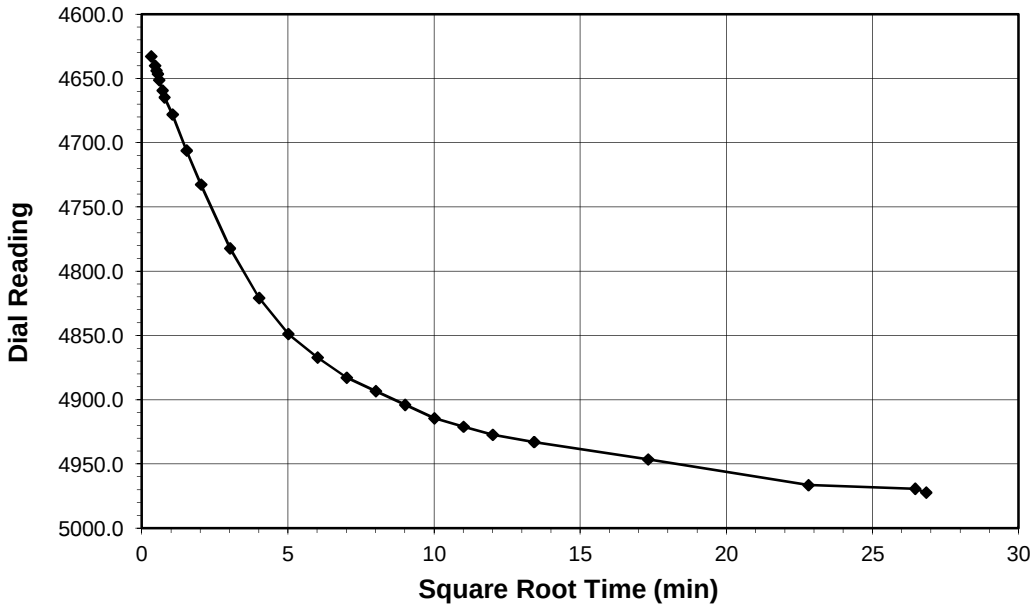
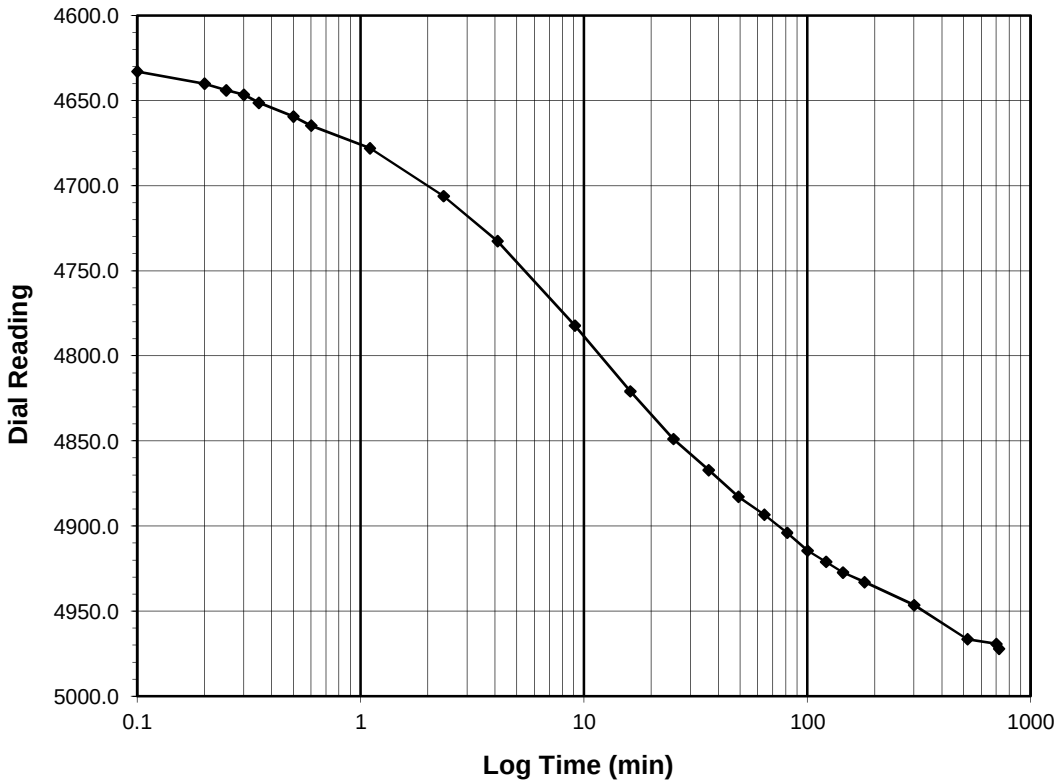
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**4 - 8**
Final Reading	**(div)**	**4972.1**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/15/19
Start Time		19:25:21

Elapsed Time (min)	Dial Reading (div)
Initial	**4593.7**
0.10	4632.8
0.20	4640.0
0.25	4643.9
0.30	4646.5
0.35	4651.2
0.50	4659.3
0.60	4664.6
1.10	4678.0
2.35	4706.1
4.10	4732.5
9.10	4782.2
16.10	4820.8
25.10	4848.8
36.12	4867.1
49.12	4882.8
64.12	4893.3
81.12	4903.9
100.12	4914.4
121.12	4921.0
144.12	4927.3
180.12	4933.0
300.12	4946.5
520.12	4966.5
700.12	4969.2
720.17	4972.1

Tested By TM *Date* 5/15/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2

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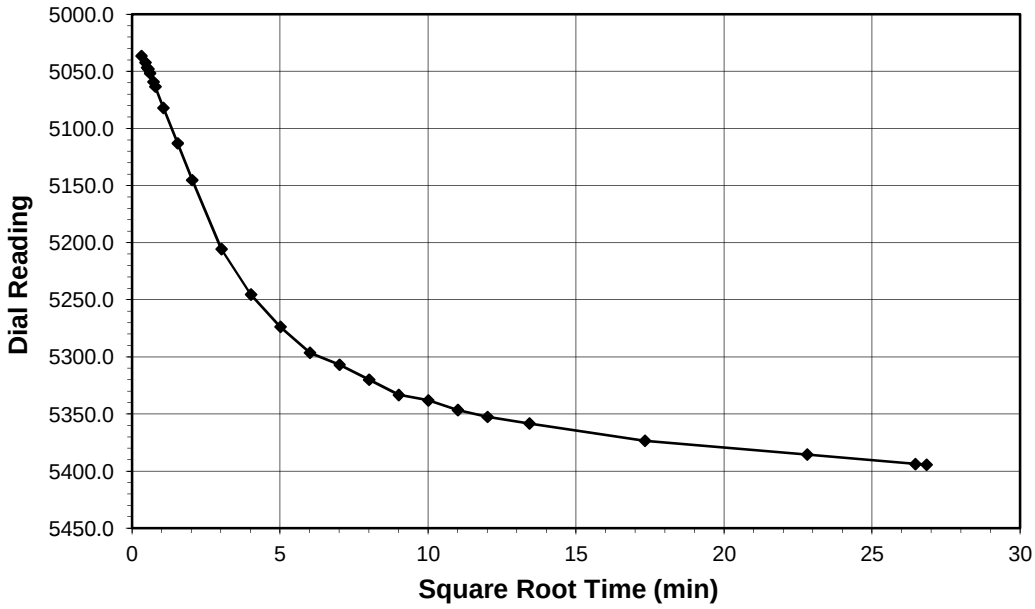
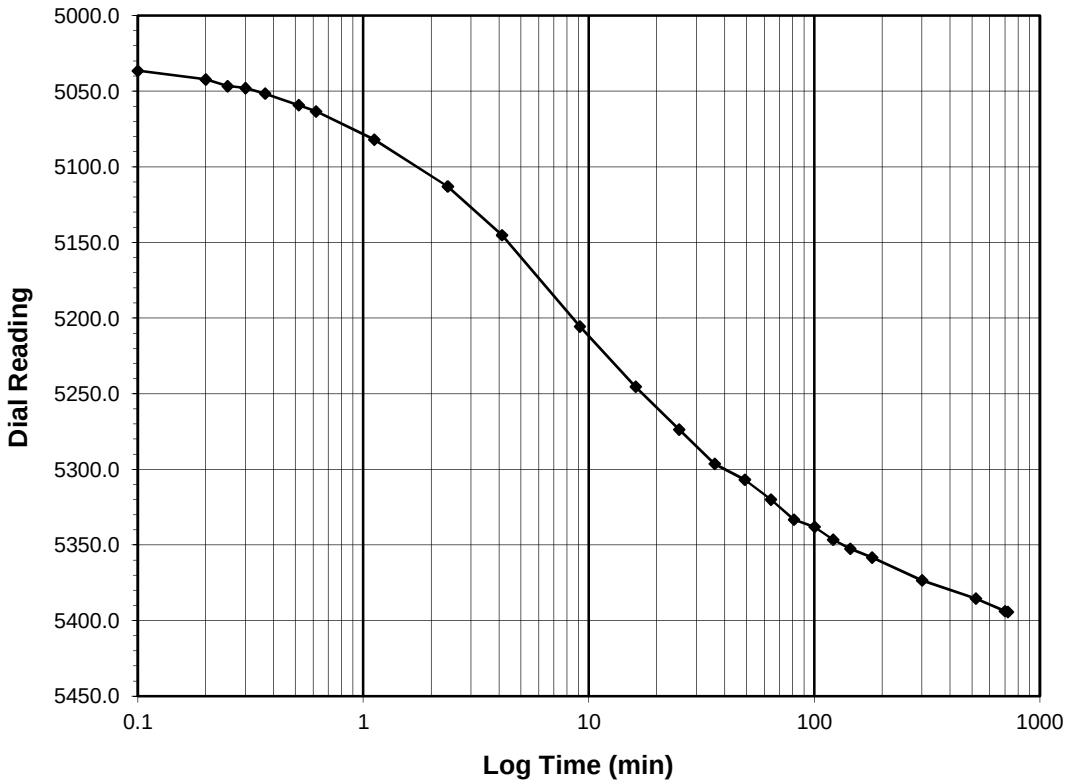
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**8 - 16**
Final Reading	**(div)**	**5394.3**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/16/19
Start Time		7:25:31

Elapsed Time (min)	Dial Reading (div)
Initial	**4972.1**
0.10	5036.5
0.20	5042.2
0.25	5046.6
0.30	5047.9
0.37	5051.6
0.52	5059.2
0.62	5063.3
1.12	5082.0
2.37	5113.0
4.12	5145.2
9.12	5205.5
16.12	5245.3
25.12	5273.7
36.12	5296.4
49.12	5306.8
64.12	5319.9
81.12	5333.2
100.12	5338.0
121.12	5346.5
144.13	5352.5
180.13	5358.3
300.13	5373.4
520.13	5385.4
700.13	5393.8
720.42	5394.3

Tested By TM *Date* 5/16/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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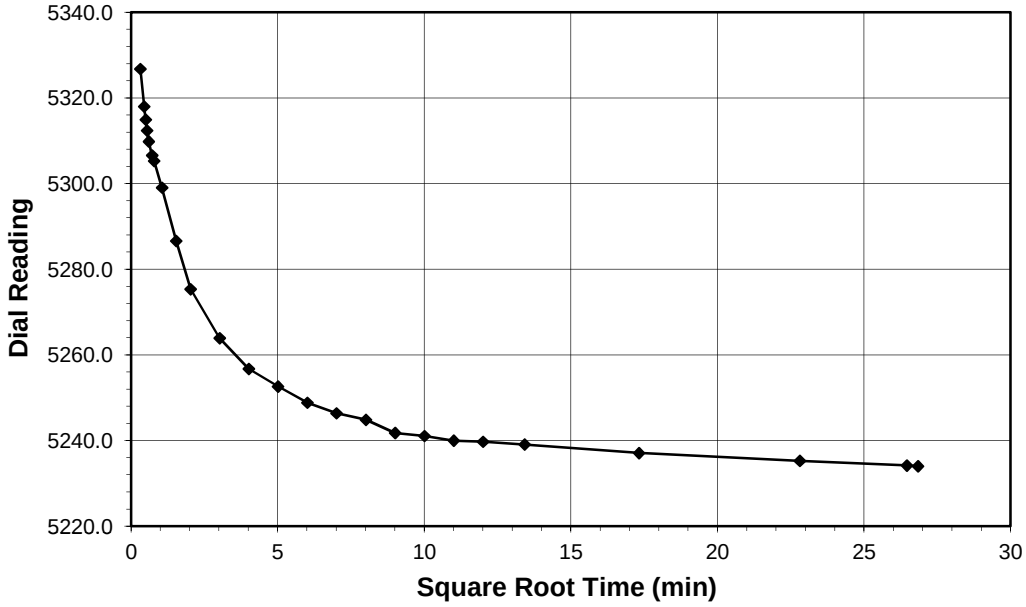
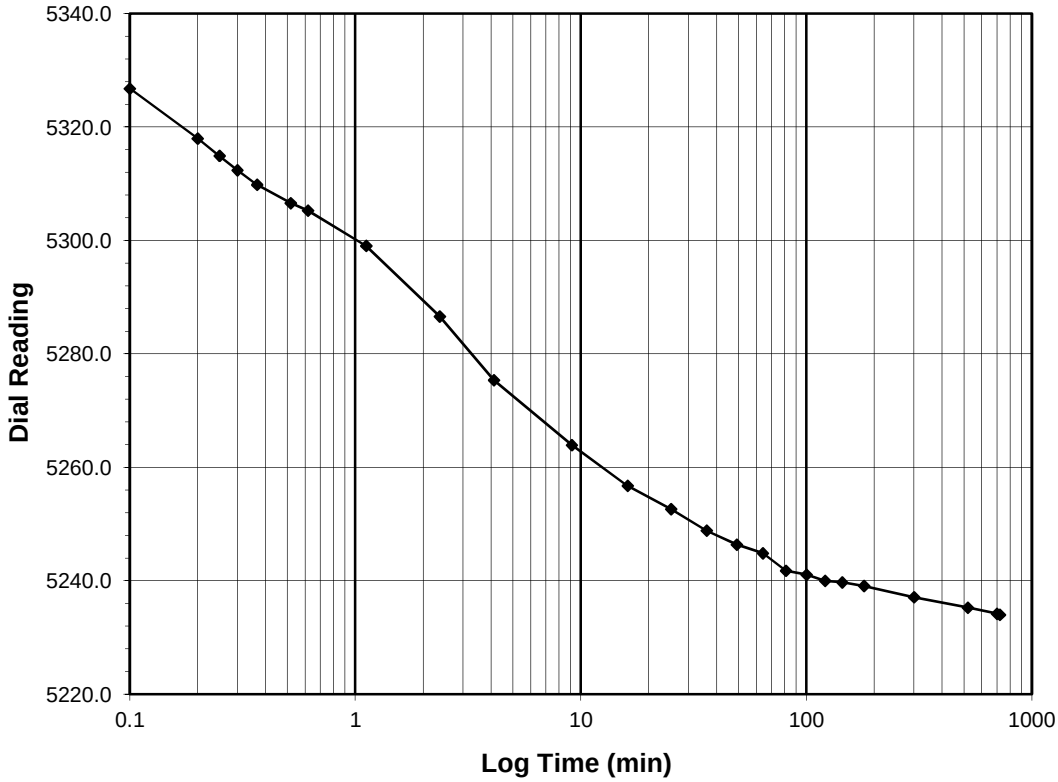
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**16 - 4**
Final Reading	**(div)**	**5234.0**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/16/19
Start Time		19:25:56

Elapsed Time (min)	Dial Reading (div)
Initial	**5394.3**
0.10	5326.8
0.20	5318.0
0.25	5314.9
0.30	5312.4
0.37	5309.8
0.52	5306.6
0.62	5305.3
1.12	5299.0
2.37	5286.6
4.12	5275.4
9.12	5263.9
16.12	5256.7
25.12	5252.6
36.12	5248.9
49.12	5246.4
64.12	5244.8
81.12	5241.8
100.12	5241.1
121.12	5240.0
144.12	5239.7
180.13	5239.1
300.13	5237.1
520.13	5235.3
700.13	5234.2
720.38	5234.0

Tested By TM *Date* 5/16/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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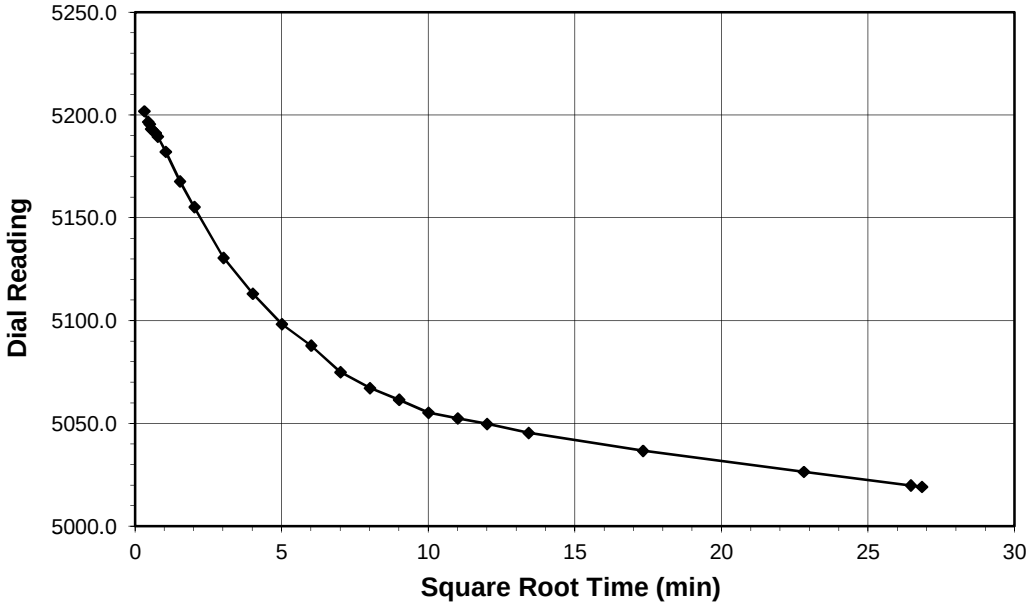
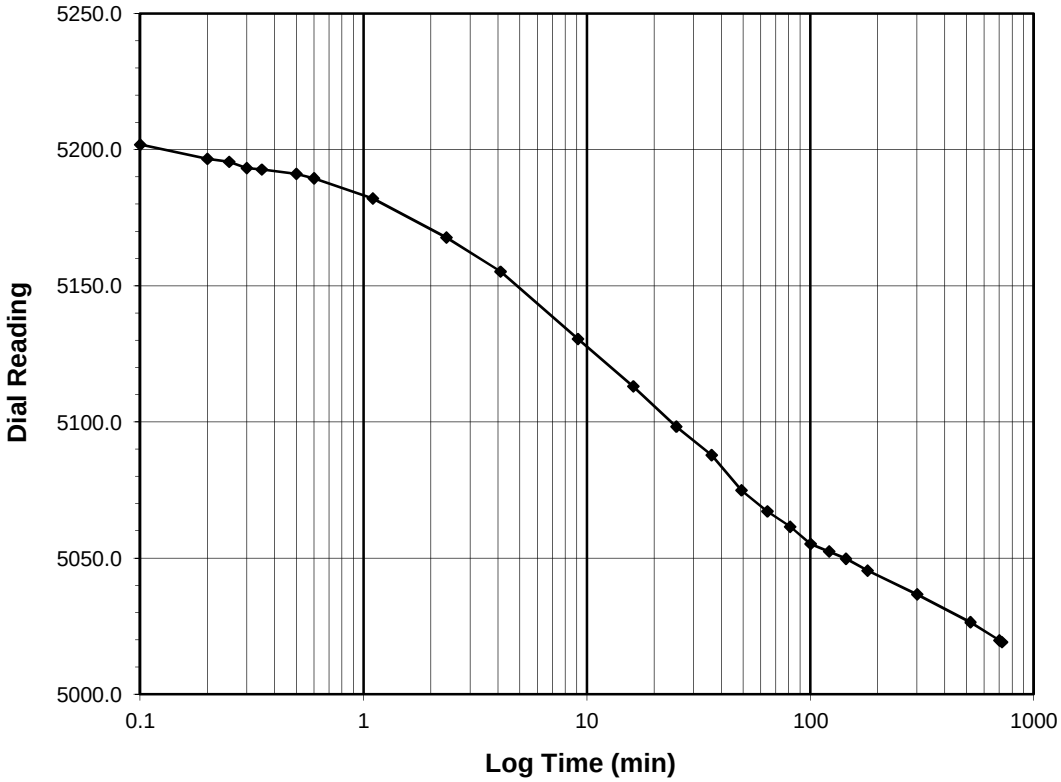
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**4 - 1**
Final Reading	**(div)**	**5019.1**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/17/19
Start Time		7:26:20

Elapsed Time (min)	Dial Reading (div)
Initial	**5234.0**
0.10	5201.9
0.20	5196.6
0.25	5195.6
0.30	5193.3
0.35	5192.7
0.50	5191.2
0.60	5189.5
1.10	5182.1
2.35	5167.7
4.10	5155.2
9.10	5130.5
16.10	5113.1
25.10	5098.3
36.10	5087.9
49.12	5074.9
64.12	5067.2
81.12	5061.5
100.12	5055.2
121.12	5052.5
144.12	5049.8
180.12	5045.4
300.12	5036.7
520.12	5026.5
700.12	5019.8
720.15	5019.1

Tested By TM *Date* 5/17/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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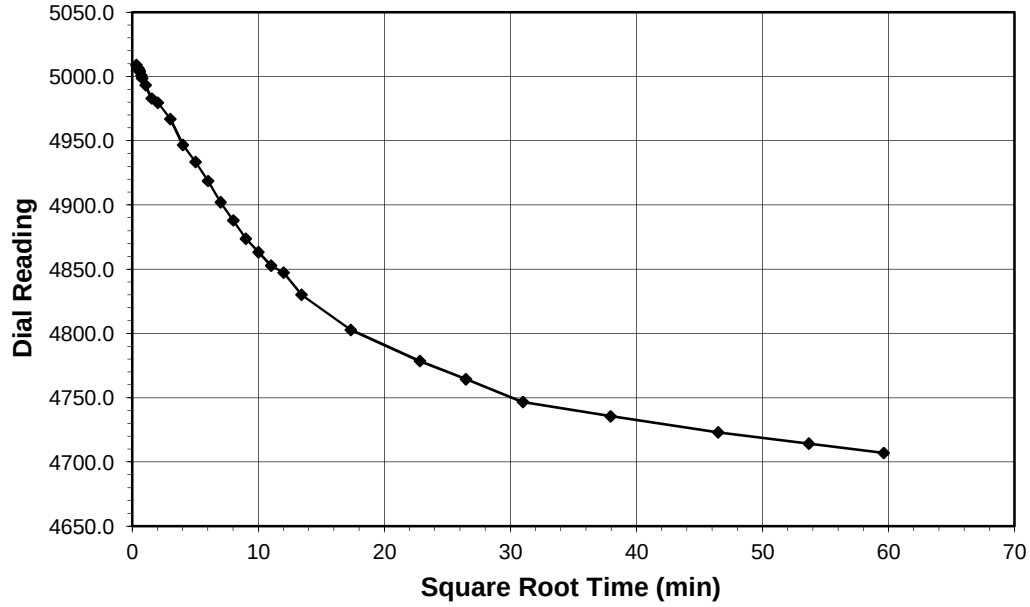
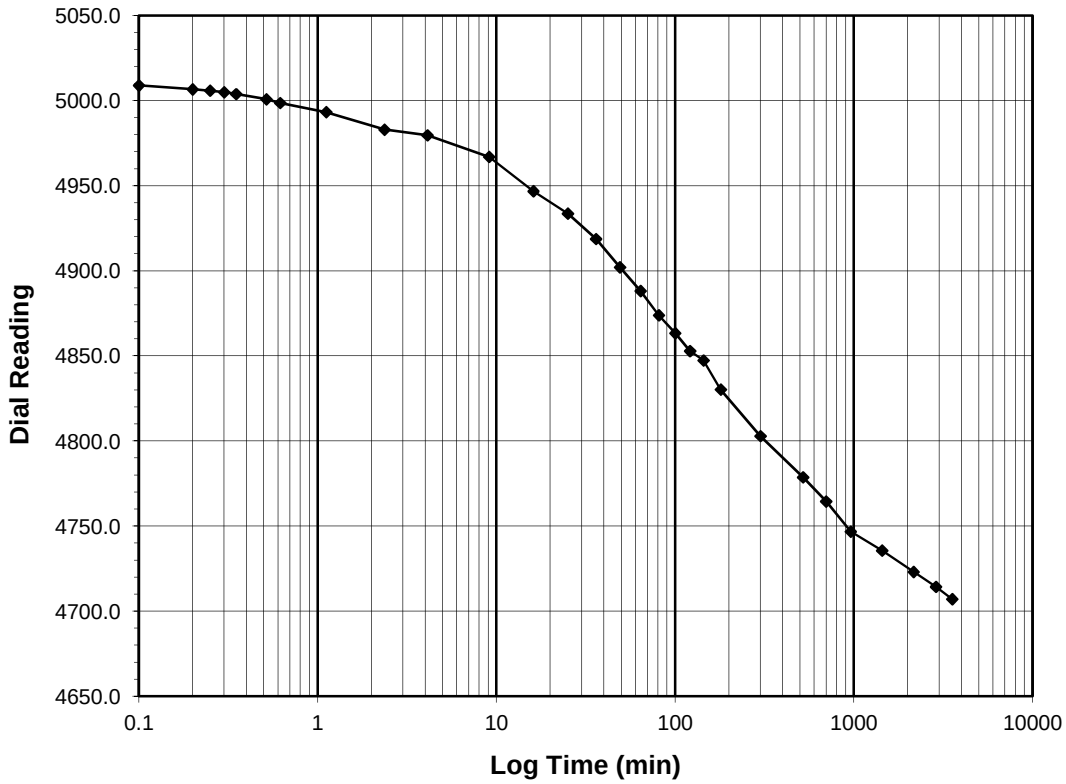
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 0.25**
Final Reading	**(div)**	**4707.0**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/17/19
Start Time		19:26:29

Elapsed Time (min)	Dial Reading (div)
Initial	**5019.1**
0.10	5009.0
0.20	5006.7
0.25	5005.9
0.30	5005.0
0.35	5003.9
0.52	5000.9
0.62	4998.7
1.12	4993.3
2.37	4983.0
4.12	4979.7
9.12	4966.9
16.12	4946.8
25.12	4933.6
36.12	4918.7
49.12	4902.1
64.12	4888.1
81.12	4873.8
100.12	4863.4
121.12	4852.9
144.12	4847.4
180.12	4830.2
300.12	4802.9
520.12	4778.6
700.12	4764.5
960.13	4746.7
1440.13	4735.6
2160.13	4723.1
2880.13	4714.3
3553.42	4707.0

Tested By TM *Date* 5/17/19 *Checked By* NJM *Date* 5/21/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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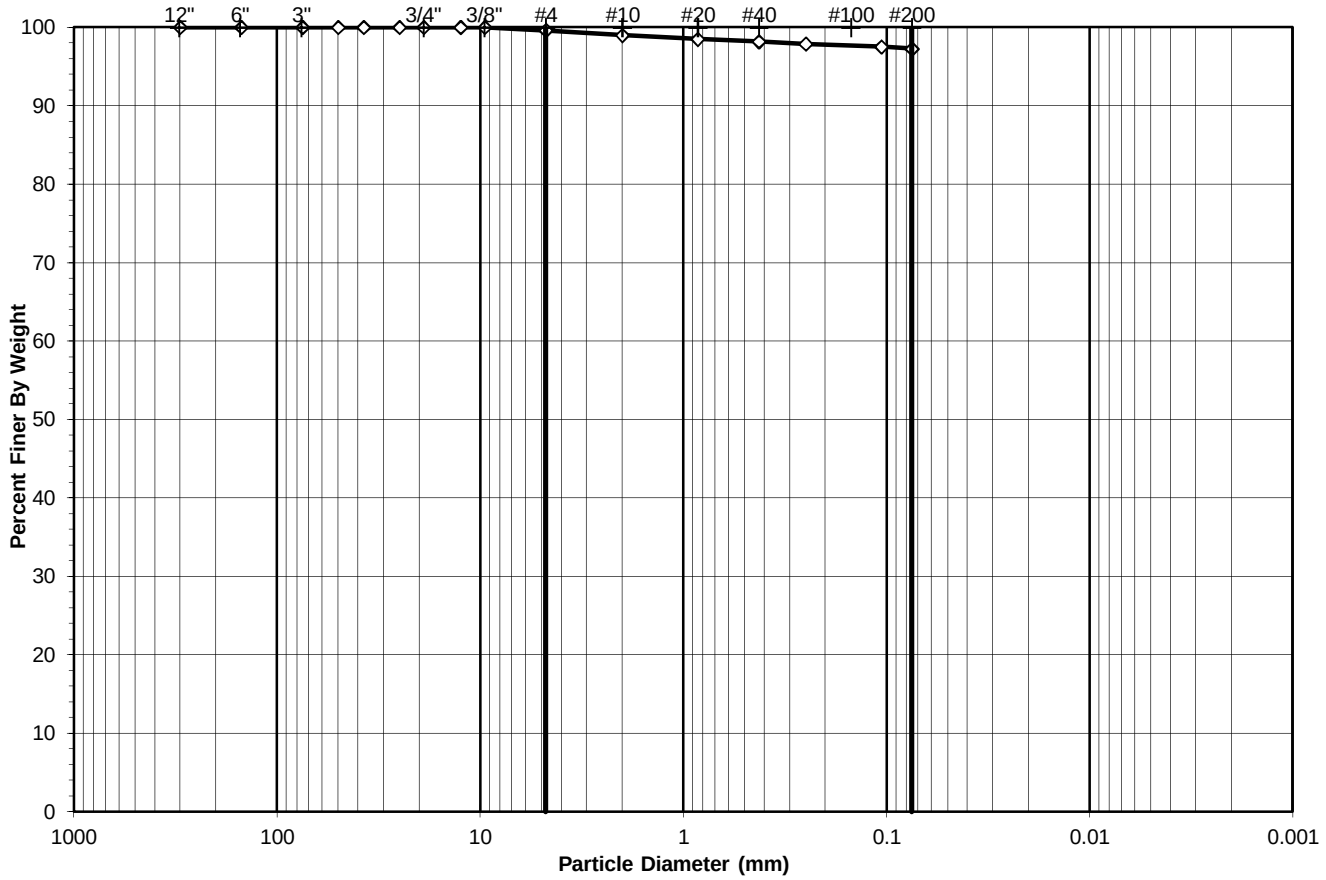
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.7-17.2
Project No.:	2019-264-001	Sample No.:	ST-1B
Lab ID:	2019-264-001-002	Soil Color:	Gray

	SIEVE ANALYSIS			*HYDROMETER*	
USCS	**cobbles**	**gravel**	**sand**	**silt and clay fraction**	
USDA	**cobbles**	**gravel**	**sand**	**silt**	**clay**



USCS Summary

Sieve Sizes (mm)		**Percentage**
Greater Than #4	*Gravel*	0.37
#4 To #200	*Sand*	2.36
Finer Than #200	*Silt & Clay*	97.27

USCS Symbol:
MH, TESTED

USCS Classification:
ELASTIC SILT

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

S:Excel\Excel QA\Spreadsheets\SieveHydJ.xls

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.7-17.2
Project No.:	2019-264-001	Sample No.:	ST-1B
Lab ID:	2019-264-001-002	Soil Color:	Gray

Moisture Content of Passing 3/4" Material		Moisture Content of Retained 3/4" Material	
Tare No.:	1489	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	602.53	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	414.64	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	146.57	Weight of Tare (g):	NA
Weight of Water (g):	187.89	Weight of Water (g):	NA
Weight of Dry Soil (g):	268.07	Weight of Dry Soil (g):	NA
Moisture Content (%):	**70.1**	**Moisture Content (%):**	**0.0**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	268.07
Dry Weight of - 3/4" Sample (g):	268.1	Weight of Minus #200 Material (g):	260.75
Wet Weight of +3/4" Sample (g):	0.00	Weight of Plus #200 Material (g):	7.32
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	268.1		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25.0	0.00		0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00		0.00	0.00	100.00	**100.00**
1/2"	12.5	0.00		0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00		0.00	0.00	100.00	**100.00**
#4	4.75	0.99		0.37	0.37	99.63	**99.63**
#10	2.00	1.73		0.65	1.01	98.99	**98.99**
#20	0.85	1.31	(**)	0.49	1.50	98.50	**98.50**
#40	0.425	0.81		0.30	1.81	98.19	**98.19**
#60	0.250	0.80		0.30	2.10	97.90	**97.90**
#140	0.106	1.01		0.38	2.48	97.52	**97.52**
#200	0.075	0.67		0.25	2.73	97.27	**97.27**
Pan	-	260.75		97.27	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Sample*

Tested By HL Date 5/14/19 Checked By KC Date 5/16/19

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

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Atterberg Limits with Organic Content Test*

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.7-17.2
Project No.:	2019-264-001	Sample No.:	ST-1B
Lab ID:	2019-264-001-002	Soil Description:	GRAY ELASTIC SILT

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

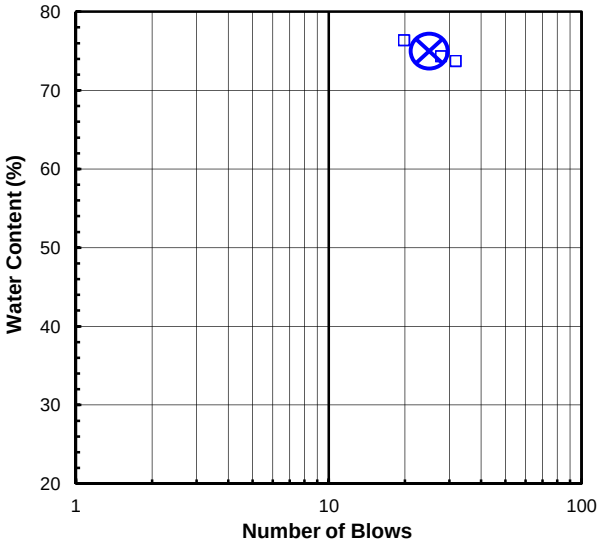
As Received Moisture Content ASTM D2216-10		Liquid Limit Standard Preparation			Liquid Limit *Dried at 110° Prior to Testing		
		1	2	3	4	5	6
Tare Number	1489	12	342	612	178	180	2983
Wt. of Tare & Wet Sample (g)	602.53	39.54	40.35	41.09	36.29	36.20	38.59
Wt. of Tare & Dry Sample (g)	414.64	31.14	31.77	31.88	29.96	30.32	31.22
Wt. of Tare (g)	146.57	19.73	20.21	19.80	18.41	19.66	18.06
Wt. of Water (g)	187.9	8.4	8.6	9.2	6.3	5.9	7.4
Wt. of Dry Sample (g)	268.1	11.4	11.6	12.1	11.6	10.7	13.2
Was As Received MC Preserved:	Yes						
Moisture Content (%)	**70.1**	**73.6**	**74.2**	**76.2**	**54.8**	**55.2**	**56.0**
Number of Blows		**32**	**28**	**20**	**32**	**27**	**21**

Plastic Limit Test	1	2	Range
Tare Number	158	276	
Wt. of Tare & Wet Sample (g)	23.67	23.23	
Wt. of Tare & Dry Sample (g)	22.01	21.63	
Wt. of Tare (g)	17.49	17.24	
Wt. of Water (g)	1.7	1.6	
Wt. of Dry Sample (g)	4.5	4.4	
Moisture Content (%)	**36.7**	**36.4**	**0.3**

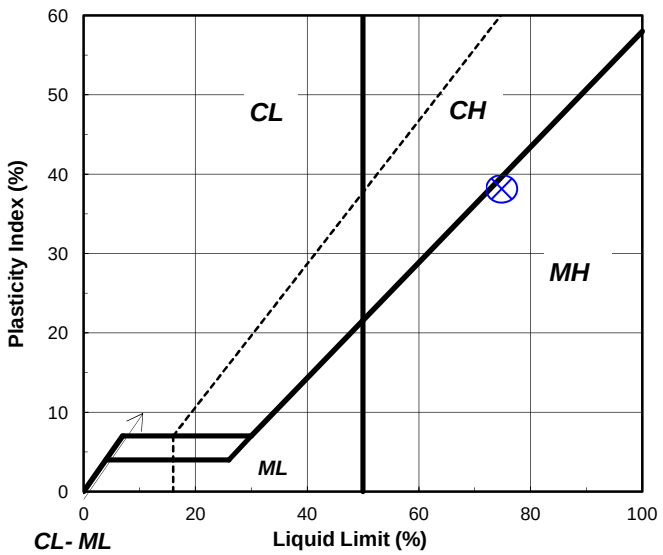
Note: The acceptable range of the two Moisture contents is ± 1.4

Test Results	Standard Prep	*Dried @ 110°
Liquid Limit (%)	**75**	**55**
Plastic Limit (%)	**37**	**N/A**
Plasticity Index (%)	**38**	**N/A**
USCS Symbol	**MH**	**OH**

Flow Curve



Plasticity Chart



Tested By JP *Date* 5/14/19 *Checked By* KC *Date* 5/16/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-001

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	002
Boring No.:	KB19-01
Depth (ft):	16.7-17.2
Sample No.:	ST-1B
Tare Number	GG
Weight of Tare & Wet Sample (g)	202.24
Weight of Tare & Dry Sample (g)	166.02
Weight of Tare (g)	114.79
Weight of Water (g)	36.22
Weight of Dry Sample (g)	51.23
Moisture Content	**70.7%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	163.58
Weight of Volatiles (g)	2.44
Weight of Ash (g)	48.79
Ash Content (%)	**95.2%**
Organic Matter (%)	**4.8%**

Tested By SG *Date* 5/13/19 *Checked By* BRB *Date* 5/14/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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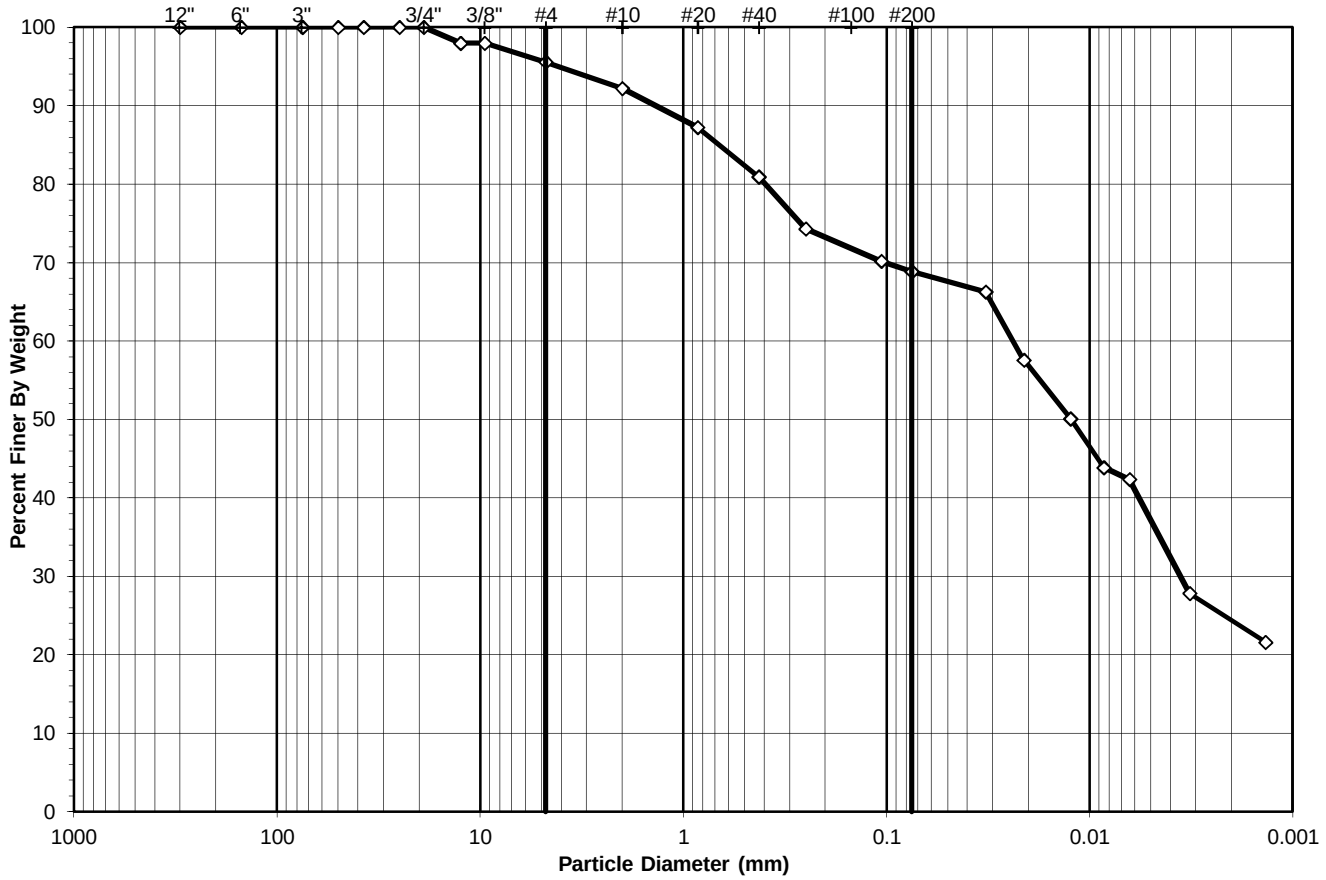
SIEVE AND HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Soil Color:	Gray

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



USCS Summary

Sieve Sizes (mm)		Percentage
Greater Than #4	*Gravel*	4.41
#4 To #200	*Sand*	26.73
Finer Than #200	*Silt & Clay*	68.86

USCS Symbol:
MH, TESTED

USCS Classification:
SANDY ELASTIC SILT

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

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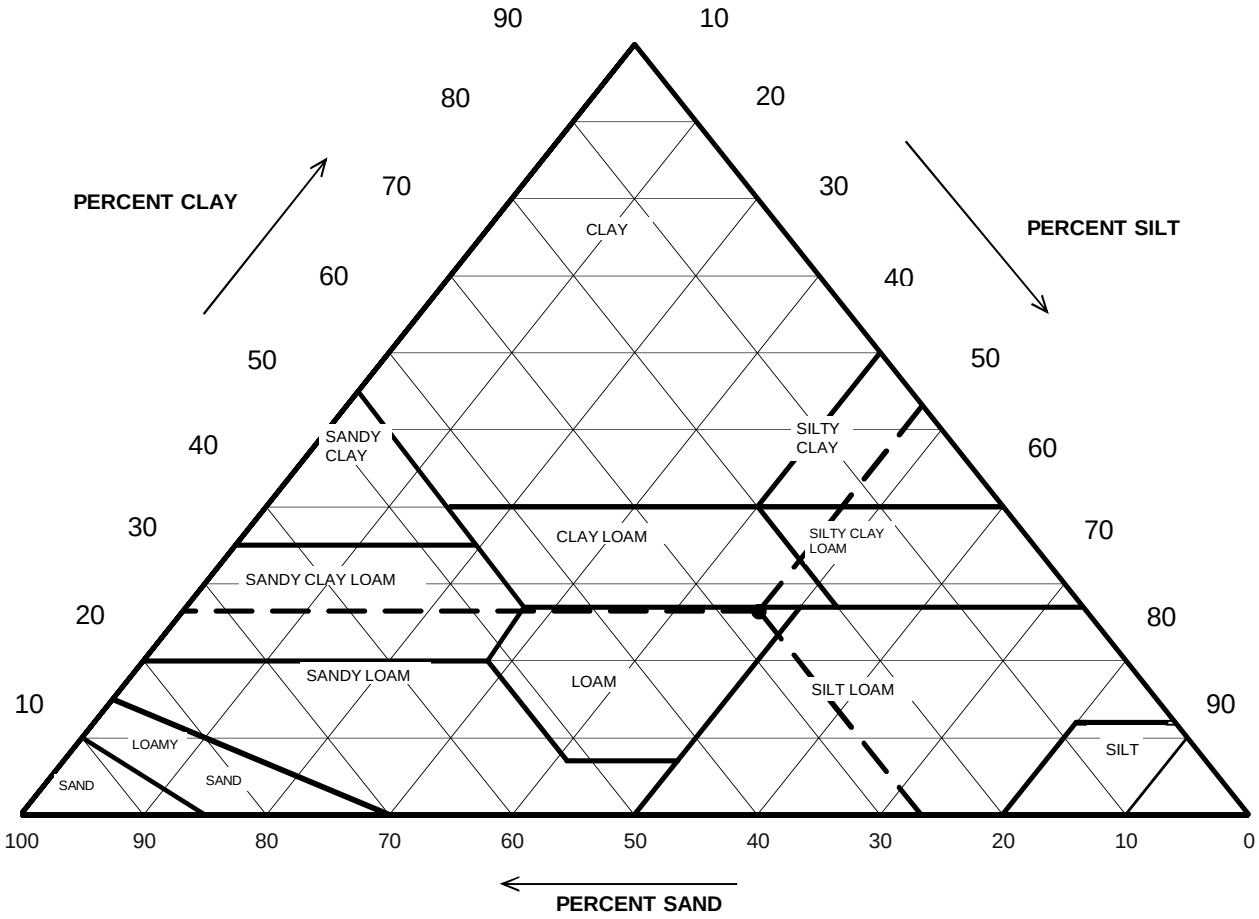
USDA CLASSIFICATION CHART

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Soil Color:	Gray



Particle Size (mm)	Percent Finer	USDA SUMMARY	Actual Percentage	Corrected % of Minus 2.0 mm material for USDA Classificat.
		Gravel	7.78	**0.00**
2	92.22	*Sand*	24.61	**26.69**
0.05	67.61	*Silt*	43.24	**46.89**
0.002	24.37	*Clay*	24.37	**26.43**

USDA Classification: ***LOAM***

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Soil Color:	Gray

Moisture Content of Passing 3/4" Material		Moisture Content of Retained 3/4" Material	
Tare No.:	1505	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	565.07	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	393.11	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	140.23	Weight of Tare (g):	NA
Weight of Water (g):	171.96	Weight of Water (g):	NA
Weight of Dry Soil (g):	252.88	Weight of Dry Soil (g):	NA
Moisture Content (%):	**68.0**	**Moisture Content (%):**	**0.0**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	252.88
Dry Weight of - 3/4" Sample (g):	252.9	Weight of Minus #200 Material (g):	174.13
Wet Weight of +3/4" Sample (g):	0.00	Weight of Plus #200 Material (g):	78.75
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	252.9		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25.0	0.00		0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00		0.00	0.00	100.00	**100.00**
1/2"	12.5	5.10		2.02	2.02	97.98	**97.98**
3/8"	9.50	0.00		0.00	2.02	97.98	**97.98**
#4	4.75	6.05		2.39	4.41	95.59	**95.59**
#10	2.00	8.53		3.37	7.78	92.22	**92.22**
#20	0.85	12.54	(**)	4.96	12.74	87.26	**87.26**
#40	0.425	16.00		6.33	19.07	80.93	**80.93**
#60	0.250	16.74		6.62	25.69	74.31	**74.31**
#140	0.106	10.42		4.12	29.81	70.19	**70.19**
#200	0.075	3.37		1.33	31.14	68.86	**68.86**
Pan	-	174.13		68.86	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Sample*

Tested By HL Date 5/15/19 Checked By KC Date 5/22/19

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HYDROMETER ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Soil Color:	Gray

Elapsed Time		R Measured	Temp.	Composite Correction	R Corrected	N	K Factor	Diameter	N'
(min)			(°C)			(%)		(mm)	(%)
0		NA	NA	NA	NA	NA	NA	NA	NA
2		33.0	22.9	6.41	26.6	96.3	0.01392	0.0325	**66.3**
5		29.5	22.9	6.41	23.1	83.6	0.01392	0.0211	**57.6**
15		26.5	22.9	6.41	20.1	72.7	0.01392	0.0124	**50.1**
33		24.0	22.9	6.41	17.6	63.7	0.01392	0.0085	**43.8**
60		23.5	22.6	6.50	17.0	61.5	0.01397	0.0064	**42.4**
250		17.5	23.1	6.34	11.2	40.4	0.01389	0.0032	**27.8**
1440		15.0	23.1	6.34	8.7	31.3	0.01389	0.0014	**21.6**

Soil Specimen Data		**Other Corrections**		
Tare No.:	976			
Wt. of Tare & Dry Material (g):	132.38	a - Factor:	1.034	
Weight of Tare (g):	98.81			
Weight of Deflocculant (g):	5.0	Percent Finer than # 200:	68.86	
Weight of Dry Material (g):	28.57			
		Specific Gravity:	2.48	Measured

Note: *Hydrometer test is performed on - # 200 sieve material.*

Tested By TO Date 5/14/19 Checked By KC Date 5/22/19

DCN: CT-S3B DATE:7/17/17 REVISION: 9e

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Atterberg Limits with Organic Content Test*

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Soil Description:	GRAY ELASTIC SILT

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

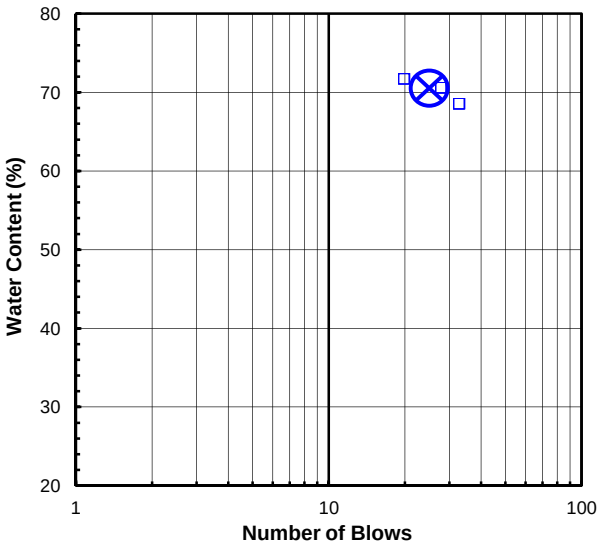
As Received Moisture Content ASTM D2216-10		Liquid Limit Standard Preparation			Liquid Limit *Dried at 110° Prior to Testing		
		1	2	3	4	5	6
Tare Number	1505	139	237	622	147	538	615
Wt. of Tare & Wet Sample (g)	565.07	39.85	39.46	42.20	35.52	40.22	39.60
Wt. of Tare & Dry Sample (g)	393.11	31.19	30.91	32.84	30.45	33.59	32.86
Wt. of Tare (g)	140.23	18.54	18.78	19.77	20.12	20.32	19.50
Wt. of Water (g)	172.0	8.7	8.6	9.4	5.1	6.6	6.7
Wt. of Dry Sample (g)	252.9	12.7	12.1	13.1	10.3	13.3	13.4
Was As Received MC Preserved:	Yes						
Moisture Content (%)	**68.0**	**68.5**	**70.5**	**71.6**	**49.1**	**50.0**	**50.4**
Number of Blows		**33**	**28**	**20**	**31**	**25**	**21**

Plastic Limit Test	1	2	Range
Tare Number	506	510	
Wt. of Tare & Wet Sample (g)	25.37	25.38	
Wt. of Tare & Dry Sample (g)	23.76	23.78	
Wt. of Tare (g)	19.31	19.26	
Wt. of Water (g)	1.6	1.6	
Wt. of Dry Sample (g)	4.5	4.5	
Moisture Content (%)	**36.2**	**35.4**	**0.8**

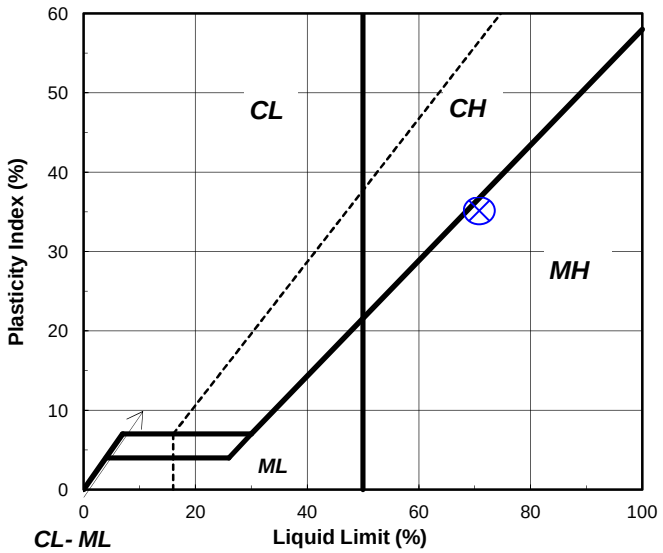
Note: The acceptable range of the two Moisture contents is ± 1.4

Test Results	Standard Prep	*Dried @ 110°
Liquid Limit (%)	**71**	**50**
Plastic Limit (%)	**36**	**N/A**
Plasticity Index (%)	**35**	**N/A**
USCS Symbol	**MH**	**OH**

Flow Curve



Plasticity Chart



Tested By JP *Date* 5/15/19 *Checked By* KC *Date* 5/17/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-001

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	004
Boring No.:	KB19-02
Depth (ft):	19.2-19.7
Sample No.:	ST-1A
Tare Number	CC
Weight of Tare & Wet Sample (g)	204.05
Weight of Tare & Dry Sample (g)	163.57
Weight of Tare (g)	115.54
Weight of Water (g)	40.48
Weight of Dry Sample (g)	48.03
Moisture Content	**84.3%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	159.74
Weight of Volatiles (g)	3.83
Weight of Ash (g)	44.20
Ash Content (%)	**92.0%**
Organic Matter (%)	**8.0%**

Tested By SG *Date* 5/14/19 *Checked By* BRB *Date* 5/15/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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SPECIFIC GRAVITY

ASTM D 854-14

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Grey Clay with Sand/Organic

(MInus No.4 sieve material,oven dried)

Replicate Number	**1**	**2**
Pycnometer ID:	G 1848	G 1917
Weight of Pycnometer & Soil & Water (g):	719.7	715.92
Temperature (^{o}C):	23.6	23.5
Weight of Pycnometer & Water (g):	686.61	684.17
Tare Number:	637	2327
Weight of Tare & Dry Soil (g):	150.06	148.58
Weight of Tare (g):	95.31	94.61
Weight of Dry Soil (g):	54.75	53.97
Specific Gravity of Soil @ Measured Temperature:	2.527	2.429
Specific Gravity of Water @ Measured Temperature:	0.99740	0.99742
Conversion Factor for Measured Temperature:	0.99919	0.99922
Specific Gravity @ 20^{o} Celsius:	2.530	2.431

Average Specific Gravity @ 20^{o} Celsius	2.48

Tested By TO *Date* 5/16/19 *Checked By* BRB *Date* 5/17/19

DCN: CT-S5 Date: 3/26/18 Revision: 21

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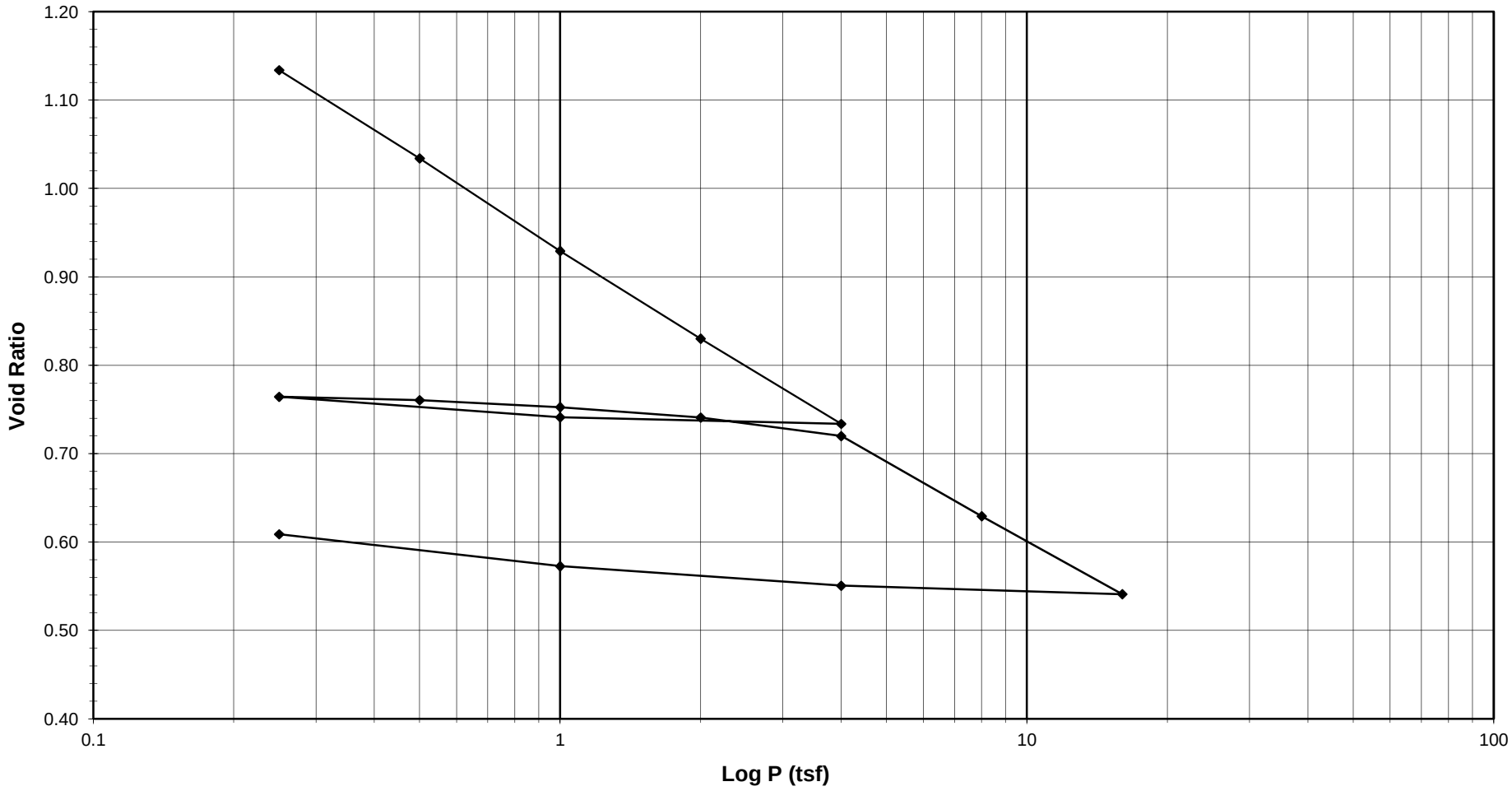
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED



Tested By TM *Date* 5/13/19 *Approved By* NJM *Date* 4/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED
Consolidometer No. G1427
1 Division = 0.0001 (in.)

Sample Properties	**Initial**	**Final**
Water Content		
Tare Number	3236	3152
Wt. of Tare & WS (g)	94.15	115.33
Wt. of Tare & DS (g)	63.88	93.45
Wt. of Water (g)	30.27	21.88
Wt. of Tare (g)	8.16	8.14
Wt. of DS (g)	55.72	85.31
Water Content (%)	54.33	25.65
Sample Parameters		
Sample Diameter (in)	2.5	2.5
Sample Height (in)	1.0000	0.6876
Sample Volume (cm^3)	80.44	55.31
Wt. of Wet Sample + Ring (g)	346.03	321.58
Wt. of Ring (g)	214.46	214.46
Wt. of Wet Sample (g)	131.57	107.12
Wet Density (pcf)	102.06	120.86
Wet Density (g/cm^3)	1.64	1.94
Water Content (%)	54.33	25.65
Wt. of Dry Sample (g)	85.26	85.26
Dry Density (pcf)	66.14	96.19
Dry Density (g/cm^3)	1.06	1.54
Void Ratio	1.3399	0.6088
Saturation (%)	100.55	104.47
Specific Gravity	2.48	*Measured*

Test Data Summary

Applied Pressure (tsf)	**Final Dial Reading** (div)	**Machine Deflection** (div)	**Corrected Reading** (div)	**Height of Sample** (mm)	**Volume** (cm^3)	**Dry Density** (g/cm^3)	**Void Ratio**
Seating	0	0	0	25.400	80.440	1.05986	**1.33993**
0.25	883.6	3.1	880.5	23.164	73.357	1.16219	**1.13390**
0.5	1315.6	8.4	1307.2	22.080	69.925	1.21924	**1.03405**
1	1777.1	22.0	1755.2	20.942	66.321	1.28549	**0.92923**
2	2217.2	38.1	2179.1	19.865	62.911	1.35516	**0.83004**
4	2654.8	64.1	2590.7	18.820	59.600	1.43045	**0.73372**
1	2592.8	33.8	2559.0	18.900	59.855	1.42435	**0.74114**
0.25	2470.4	10.6	2459.8	19.152	60.653	1.40562	**0.76435**
0.5	2488.8	12.7	2476.1	19.111	60.522	1.40866	**0.76053**
1	2534.6	24.6	2510.0	19.025	60.250	1.41503	**0.75262**
2	2598.3	38.0	2560.3	18.897	59.844	1.42461	**0.74083**
4	2713.8	64.0	2649.7	18.670	59.125	1.44194	**0.71991**
8	3136.8	99.6	3037.3	17.685	56.008	1.52219	**0.62923**
16	3571.2	156.7	3414.4	16.727	52.974	1.60937	**0.54097**
4	3457.0	83.9	3373.0	16.832	53.307	1.59932	**0.55066**
1	3315.4	36.6	3278.8	17.072	54.065	1.57690	**0.57271**
0.25	3139.0	14.6	3124.4	17.464	55.307	1.54148	**0.60884**

Tested By *TM* *Date* *5/13/19* *Input Checked By* *NJM* *Date* *4/23/19*

DCN: CT-24E Date: 8/15/12 Revision: 2

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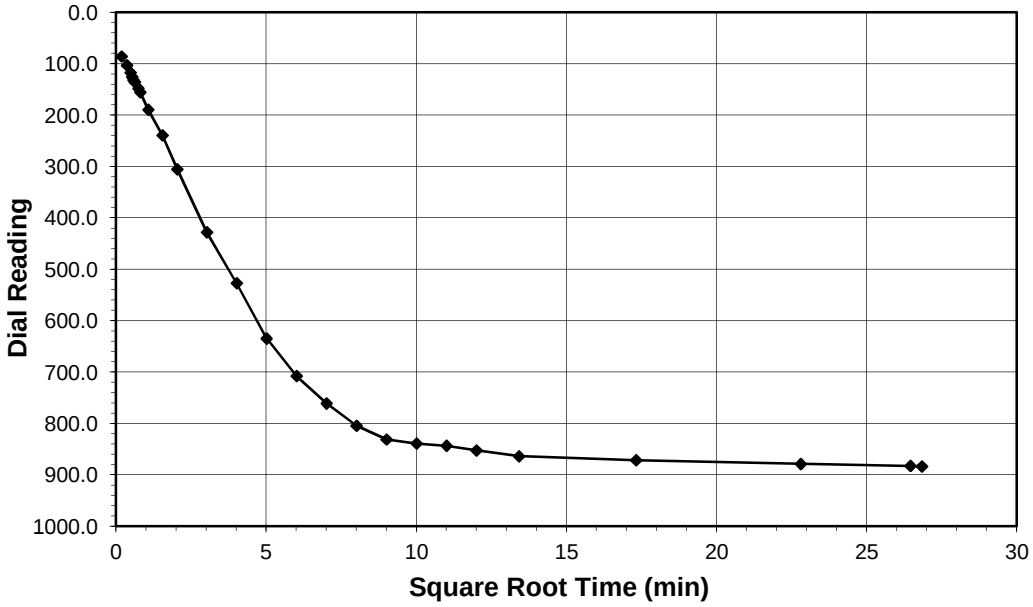
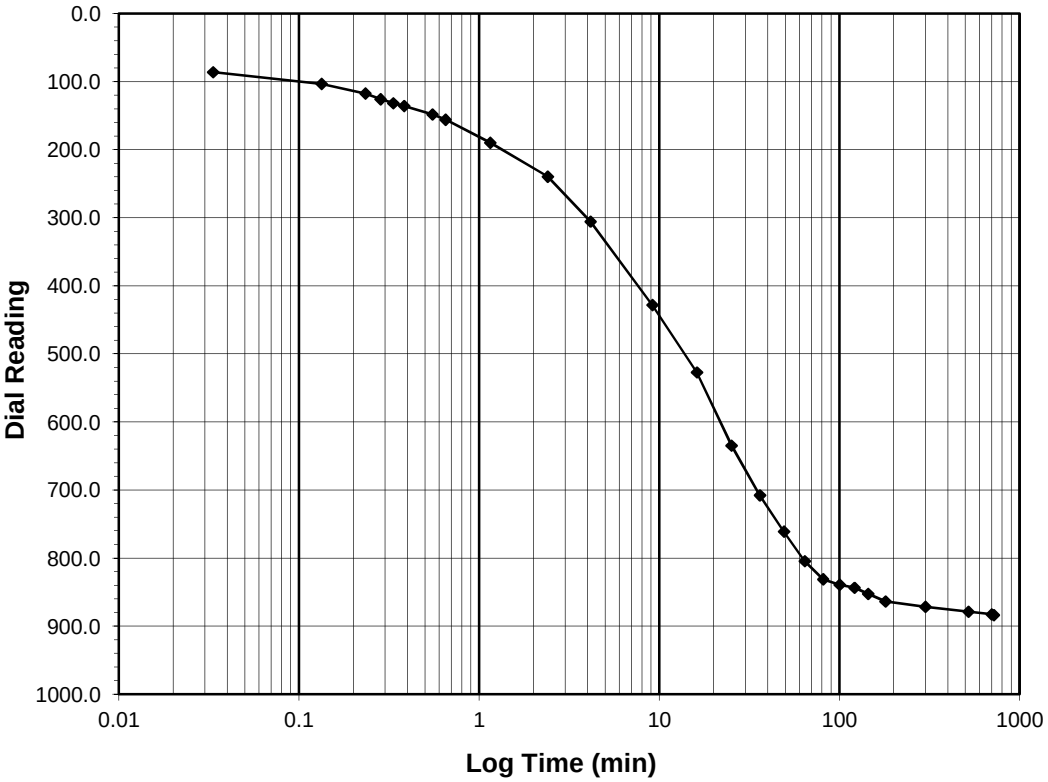
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0 - 0.25**
Final Reading	**(div)**	**883.6**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/13/19
Start Time		9:27:17

Elapsed Time (min)	Dial Reading (div)
Initial	**0.0**
0.03	86.0
0.13	103.3
0.23	117.3
0.28	125.8
0.33	131.7
0.38	135.7
0.55	148.2
0.65	155.7
1.15	189.7
2.40	239.5
4.15	305.6
9.15	428.2
16.15	527.1
25.15	634.8
36.15	707.7
49.15	761.0
64.15	804.5
81.15	831.2
100.15	839.2
121.15	843.5
144.15	852.5
180.15	863.7
300.15	871.6
520.15	878.7
700.15	882.7
720.28	883.6

Tested By TM *Date* 5/13/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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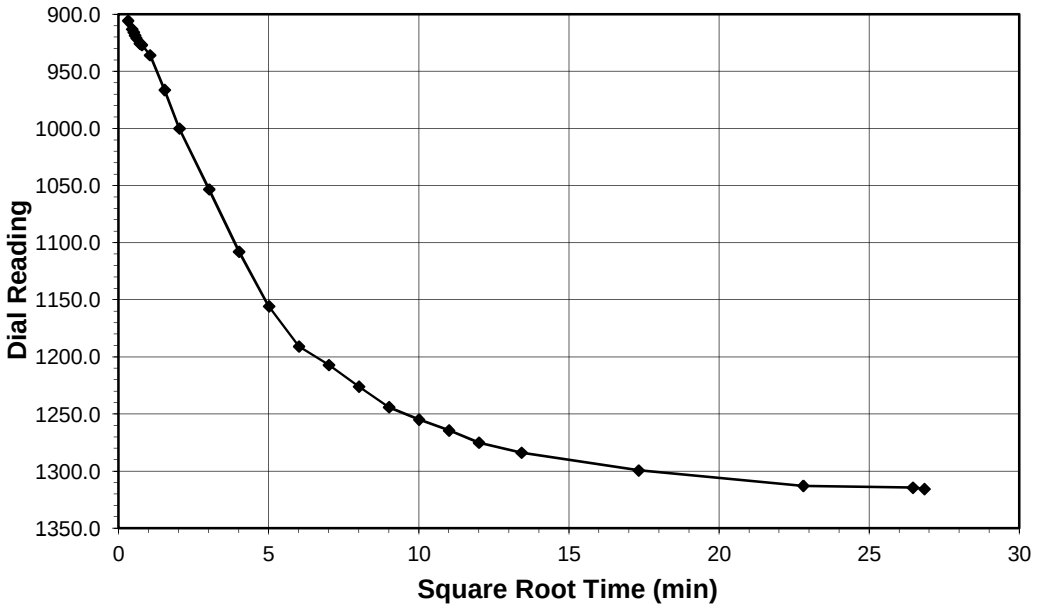
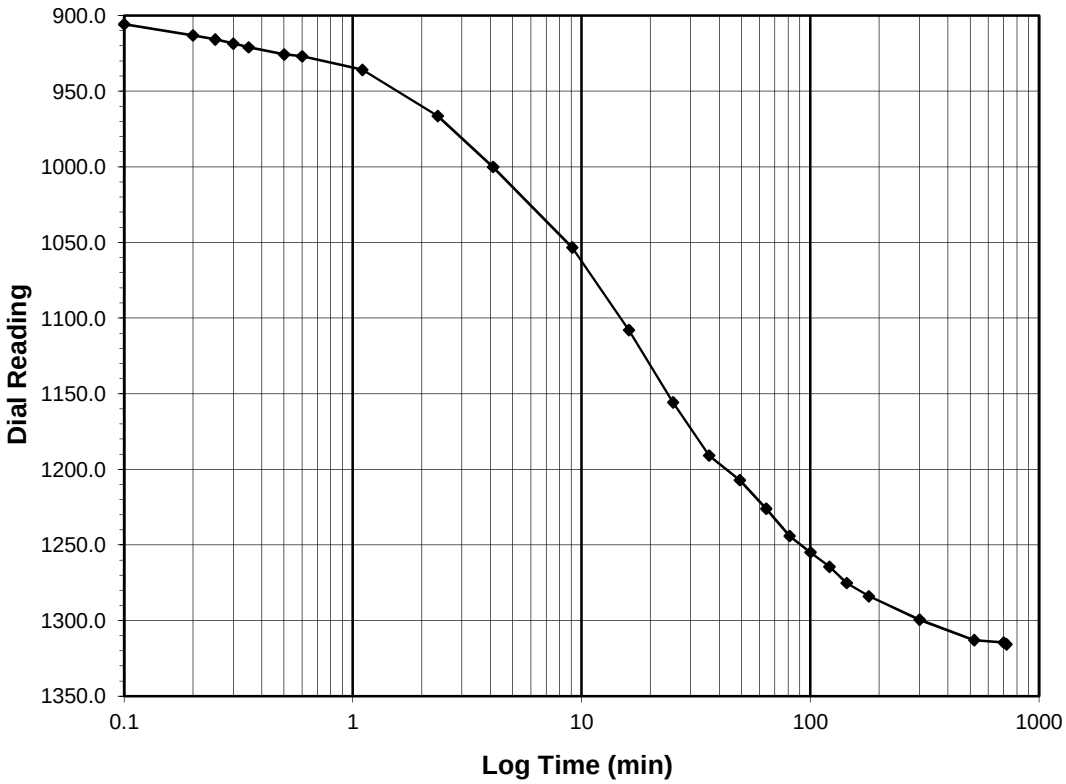
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.25 - 0.5**
Final Reading	**(div)**	**1315.6**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/13/19
Start Time		21:27:38

Elapsed Time (min)	Dial Reading (div)
Initial	**883.6**
0.10	905.7
0.20	913.1
0.25	915.8
0.30	918.5
0.35	920.9
0.50	925.6
0.60	926.9
1.10	935.9
2.35	966.4
4.10	1000.1
9.10	1053.3
16.10	1107.9
25.10	1155.7
36.10	1190.8
49.10	1207.1
64.10	1226.0
81.12	1244.0
100.12	1254.8
121.12	1264.4
144.12	1275.1
180.12	1283.9
300.12	1299.4
520.12	1312.9
700.12	1314.5
720.33	1315.6

Tested By TM *Date* 5/13/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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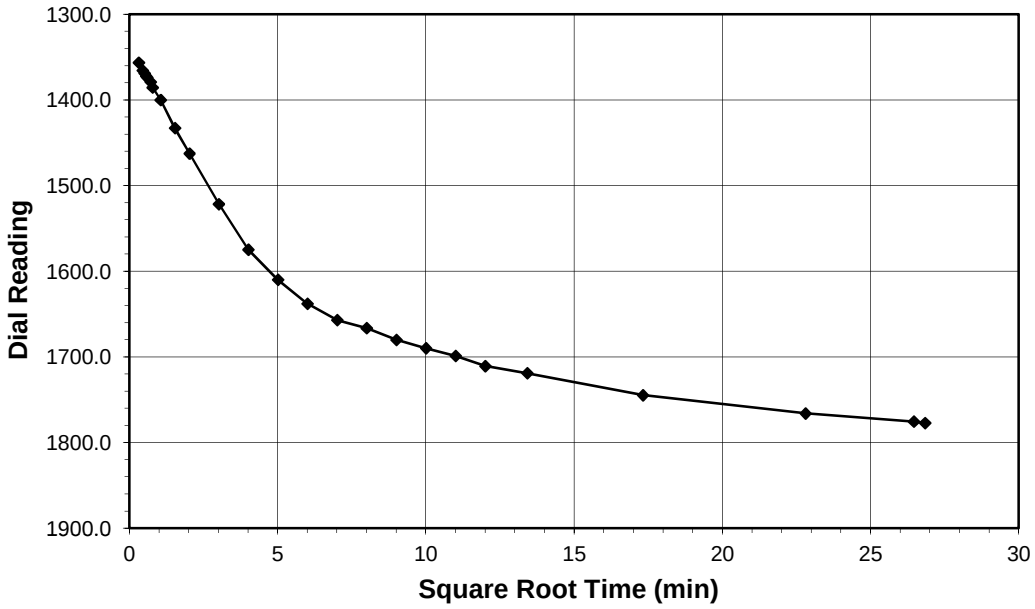
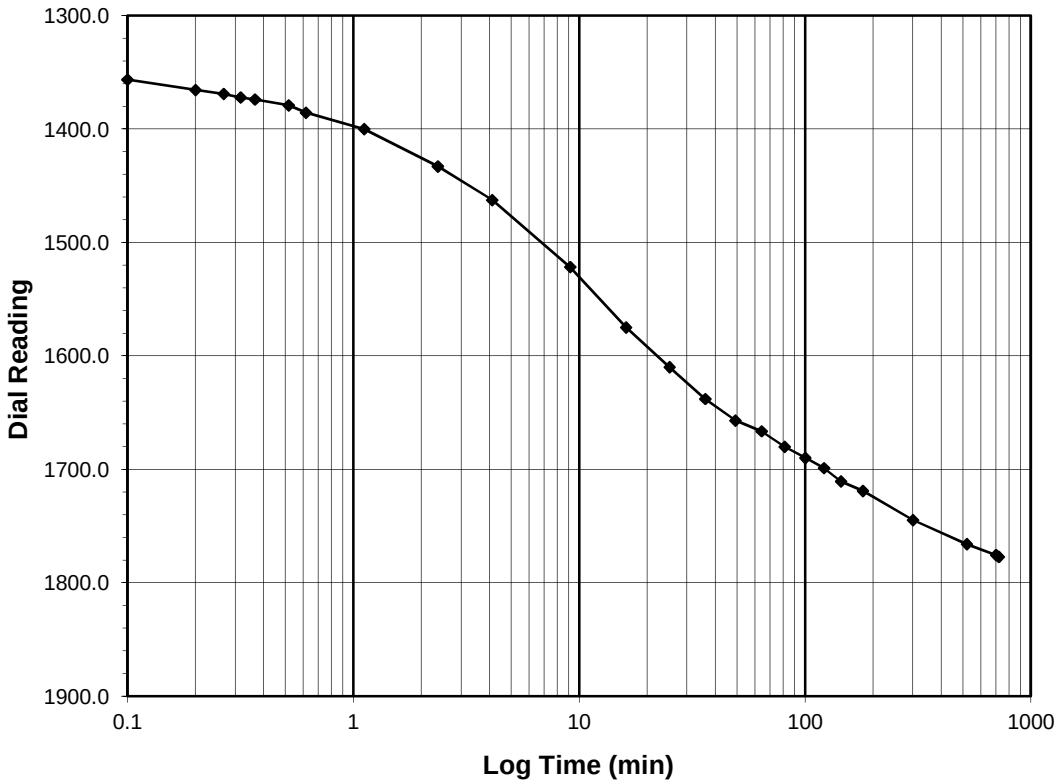
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.5 - 1**
Final Reading	**(div)**	**1777.1**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/14/19
Start Time		9:27:58

Elapsed Time (min)	Dial Reading (div)
Initial	**1315.6**
0.10	1356.5
0.20	1365.5
0.27	1369.0
0.32	1372.2
0.37	1373.9
0.52	1379.1
0.62	1385.6
1.12	1400.1
2.37	1432.9
4.12	1462.6
9.12	1521.6
16.12	1574.9
25.12	1610.0
36.12	1637.9
49.12	1657.0
64.12	1666.4
81.13	1680.1
100.13	1689.9
121.13	1698.9
144.13	1710.7
180.13	1719.0
300.13	1744.7
520.13	1766.0
700.13	1775.5
720.25	1777.1

Tested By TM *Date* 5/14/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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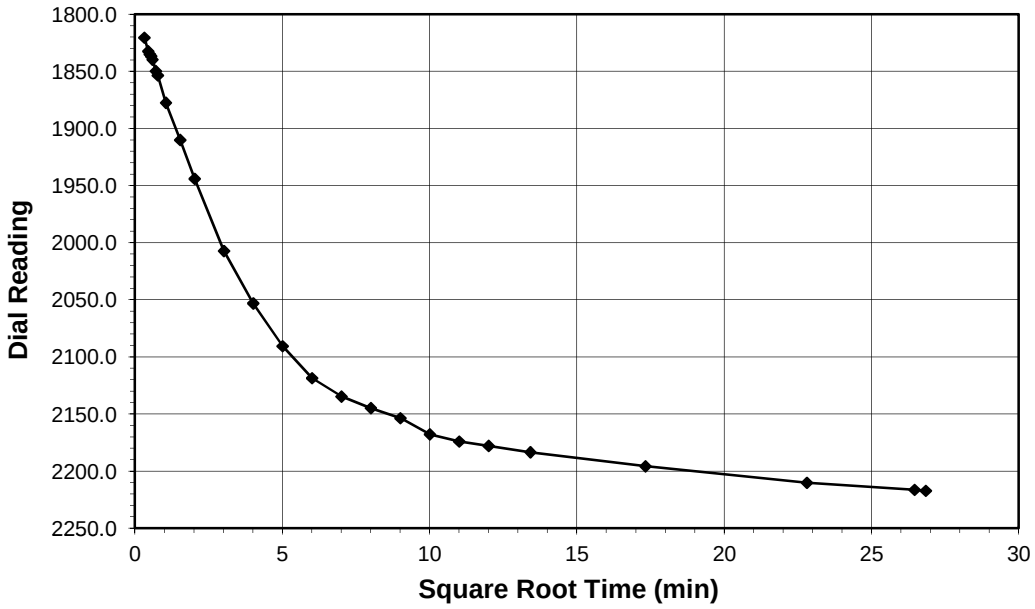
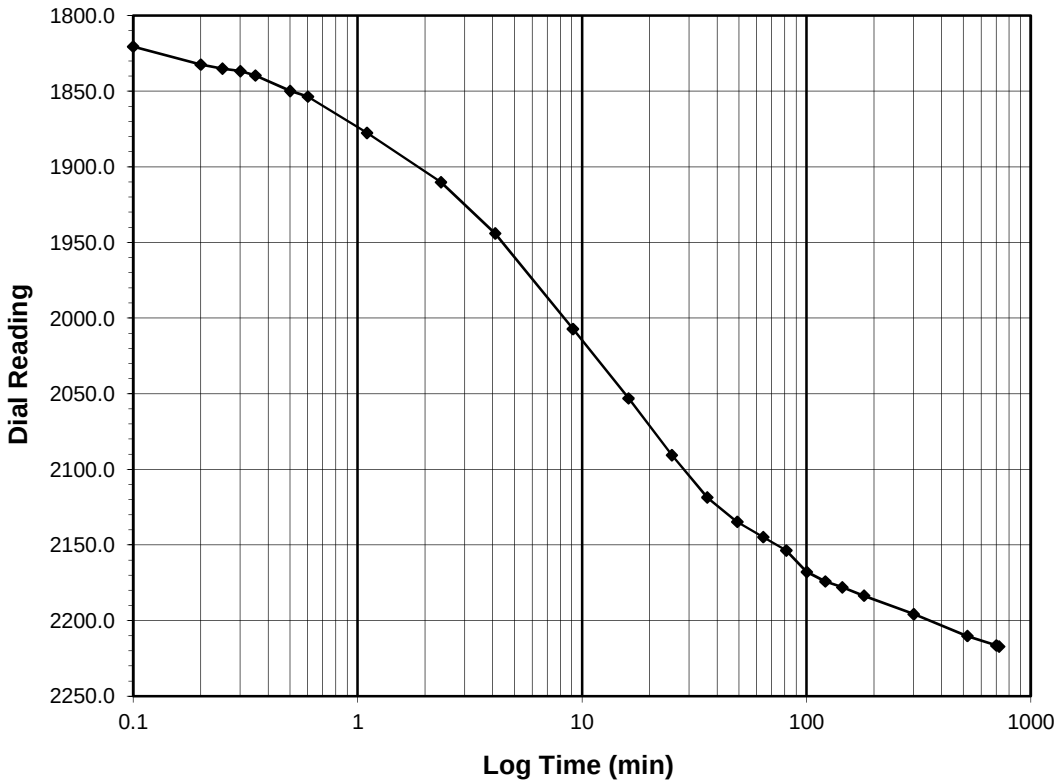
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 2**
Final Reading	**(div)**	**2217.2**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/14/19
Start Time		21:28:13

Elapsed Time (min)	Dial Reading (div)
Initial	**1777.1**
0.10	1820.5
0.20	1832.4
0.25	1835.0
0.30	1836.7
0.35	1839.6
0.50	1849.8
0.60	1853.5
1.10	1877.5
2.35	1910.1
4.10	1944.0
9.10	2007.2
16.10	2053.1
25.10	2090.6
36.10	2118.6
49.12	2134.7
64.12	2144.8
81.12	2153.6
100.12	2167.8
121.12	2174.1
144.12	2177.9
180.12	2183.5
300.12	2195.7
520.12	2210.2
700.12	2216.4
720.28	2217.2

Tested By TM *Date* 5/14/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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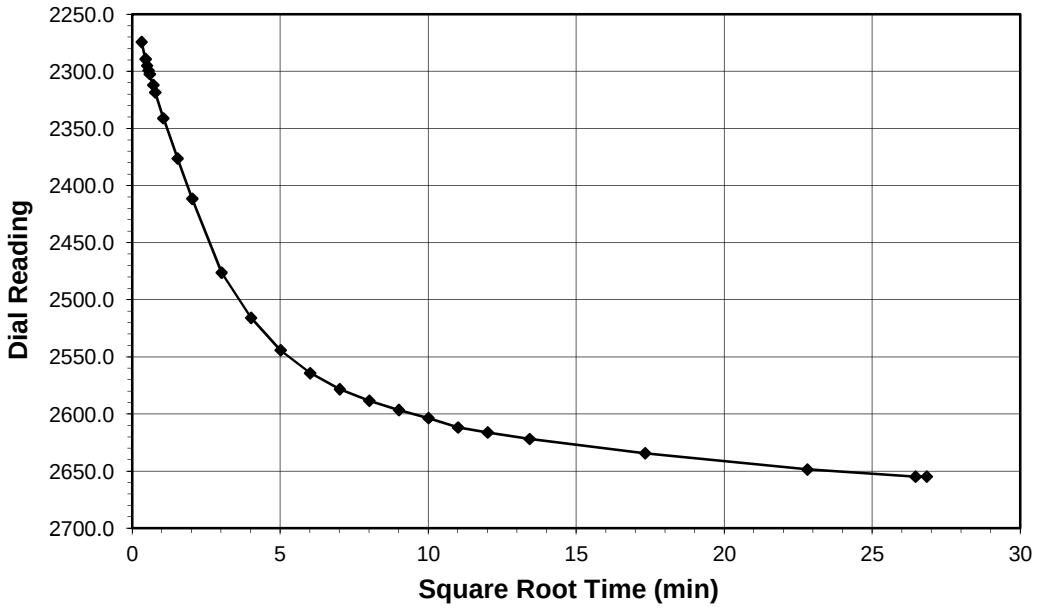
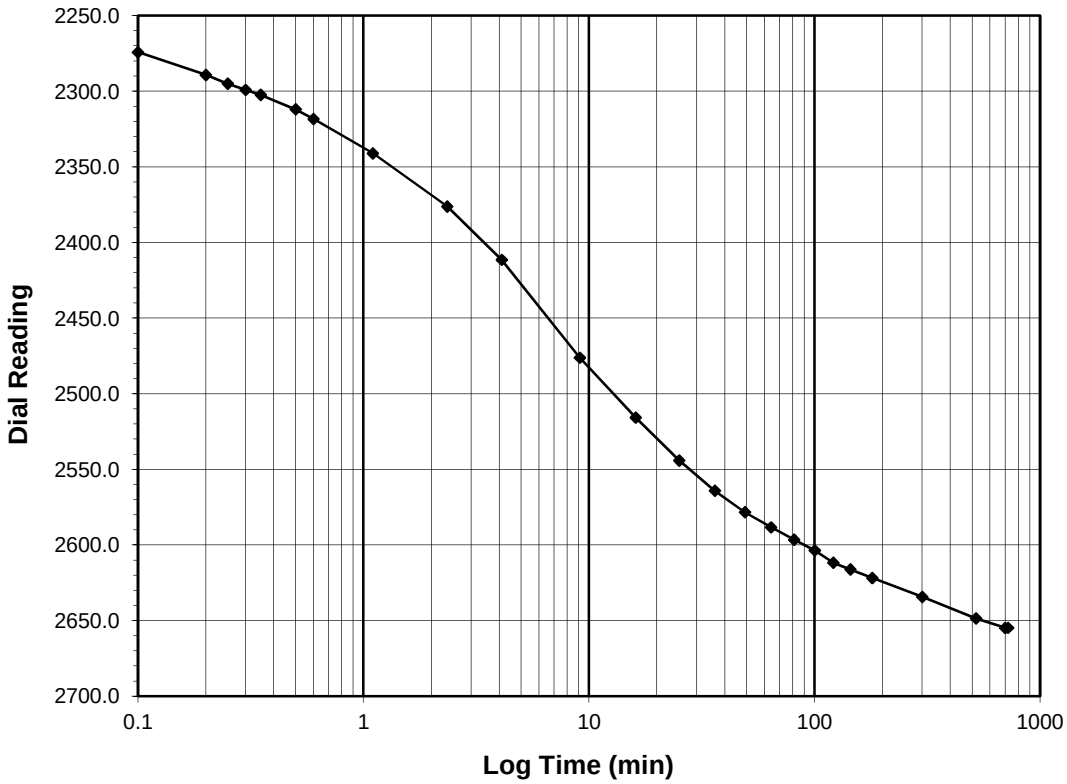
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**2 - 4**
Final Reading	**(div)**	**2654.8**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/15/19
Start Time		9:28:31

Elapsed Time (min)	Dial Reading (div)
Initial	**2217.2**
0.10	2274.2
0.20	2289.2
0.25	2295.0
0.30	2299.1
0.35	2302.4
0.50	2311.9
0.60	2318.4
1.10	2341.0
2.35	2376.2
4.10	2411.4
9.10	2476.2
16.10	2515.8
25.10	2544.1
36.12	2564.1
49.12	2578.3
64.12	2588.3
81.12	2596.5
100.12	2603.6
121.12	2611.8
144.12	2616.2
180.12	2621.8
300.12	2634.3
520.12	2648.6
700.12	2654.8
720.37	2654.7

Tested By TM *Date* 5/15/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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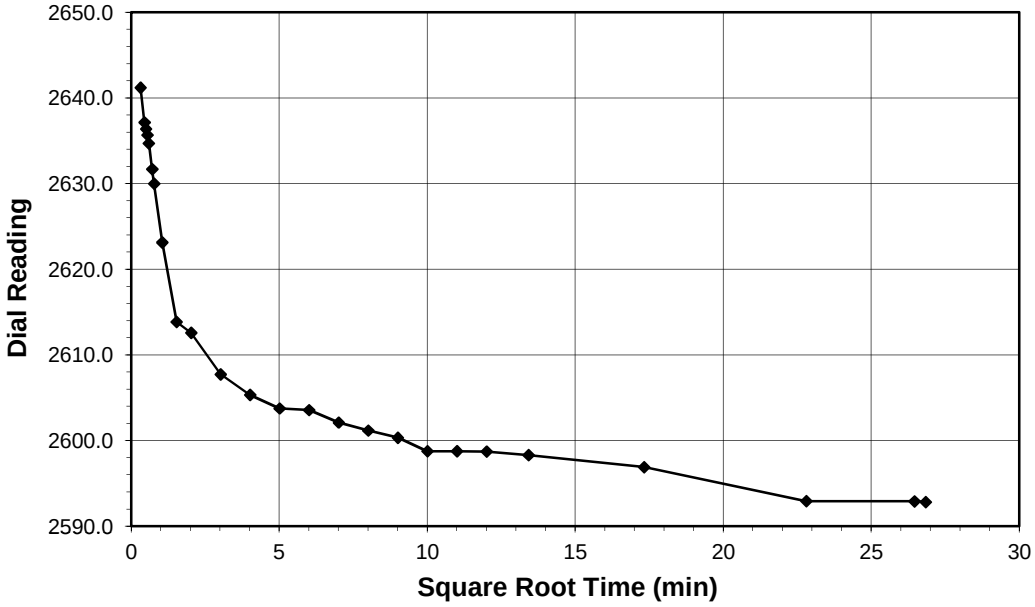
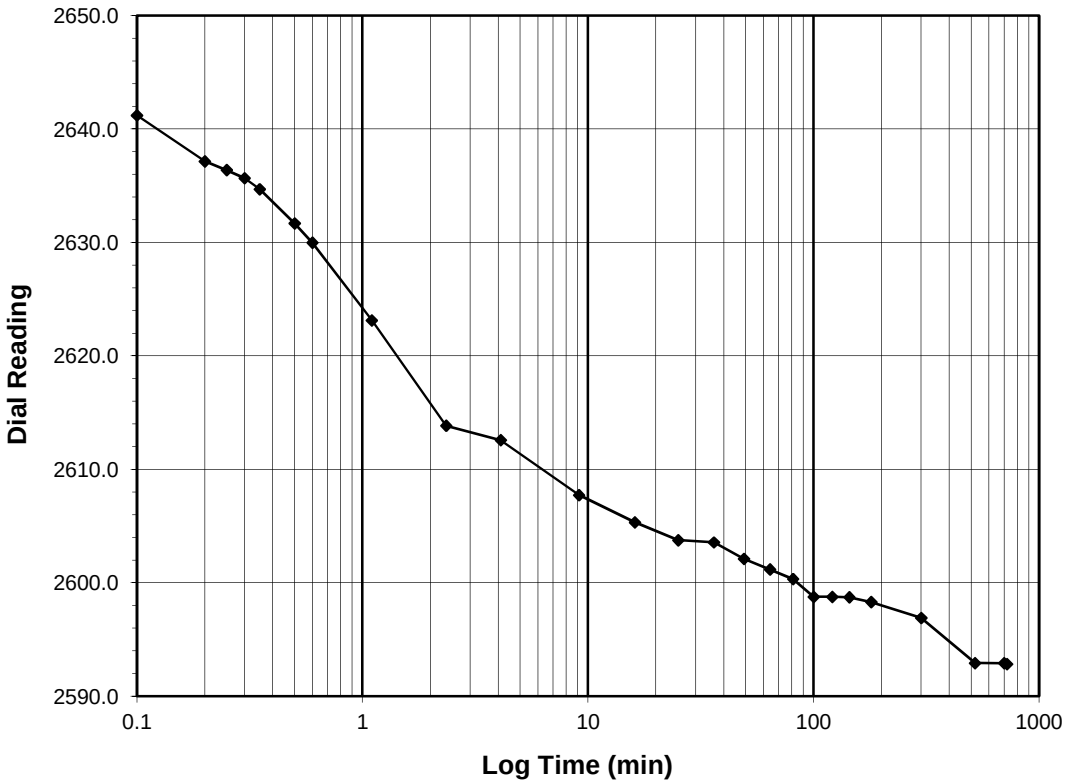
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**4 - 1**
Final Reading	**(div)**	**2592.8**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/15/19
Start Time		21:28:53

Elapsed Time (min)	Dial Reading (div)
Initial	**2654.8**
0.10	2641.2
0.20	2637.2
0.25	2636.4
0.30	2635.7
0.35	2634.7
0.50	2631.7
0.60	2630.0
1.10	2623.1
2.35	2613.8
4.10	2612.6
9.12	2607.7
16.12	2605.3
25.12	2603.8
36.12	2603.6
49.12	2602.1
64.12	2601.2
81.12	2600.3
100.12	2598.8
121.12	2598.8
144.12	2598.7
180.12	2598.3
300.12	2596.9
520.13	2592.9
700.13	2592.9
720.35	2592.8

Tested By TM *Date* 5/15/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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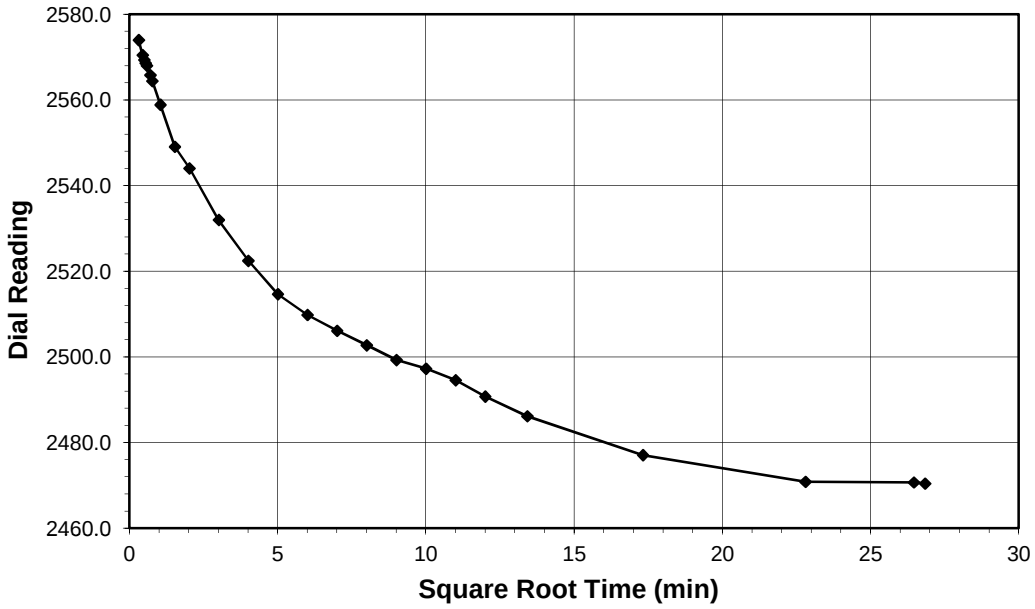
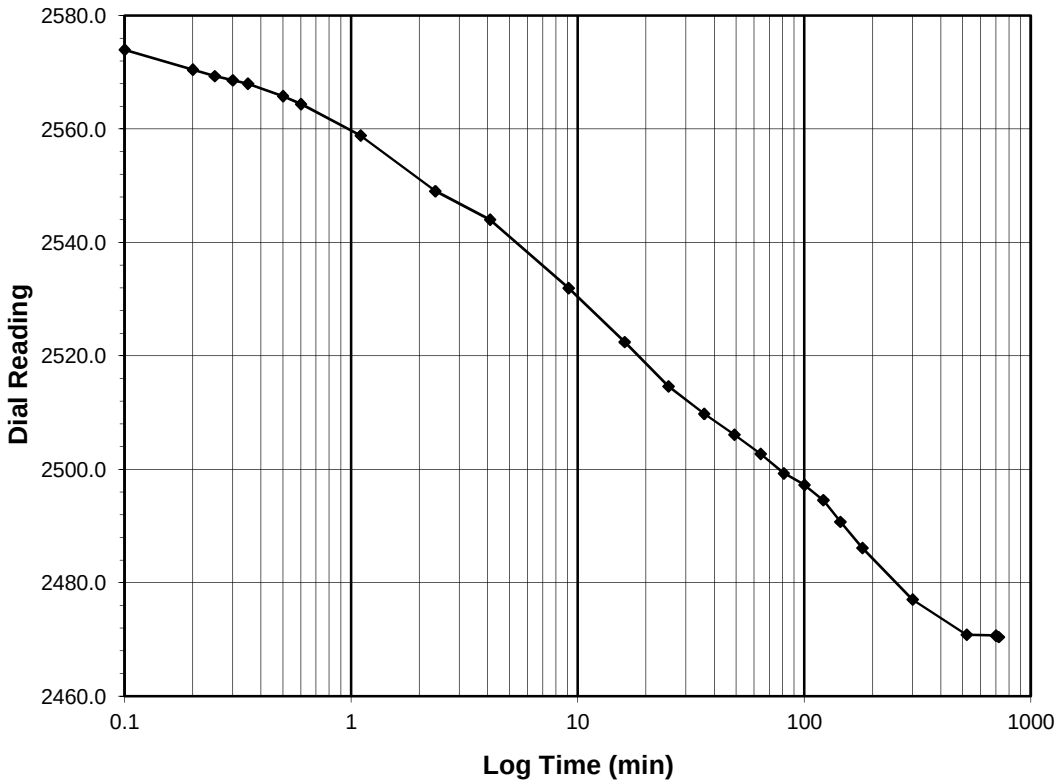
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 0.25**
Final Reading	**(div)**	**2470.4**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/16/19
Start Time		9:29:15

Elapsed Time (min)	Dial Reading (div)
Initial	**2592.8**
0.10	2574.0
0.20	2570.5
0.25	2569.3
0.30	2568.6
0.35	2568.0
0.50	2565.8
0.60	2564.4
1.10	2558.9
2.35	2549.1
4.10	2544.0
9.10	2532.0
16.10	2522.5
25.10	2514.6
36.10	2509.8
49.10	2506.1
64.10	2502.7
81.10	2499.3
100.10	2497.3
121.10	2494.6
144.10	2490.7
180.10	2486.2
300.10	2477.1
520.10	2470.8
700.10	2470.7
720.40	2470.4

Tested By TM *Date* 5/16/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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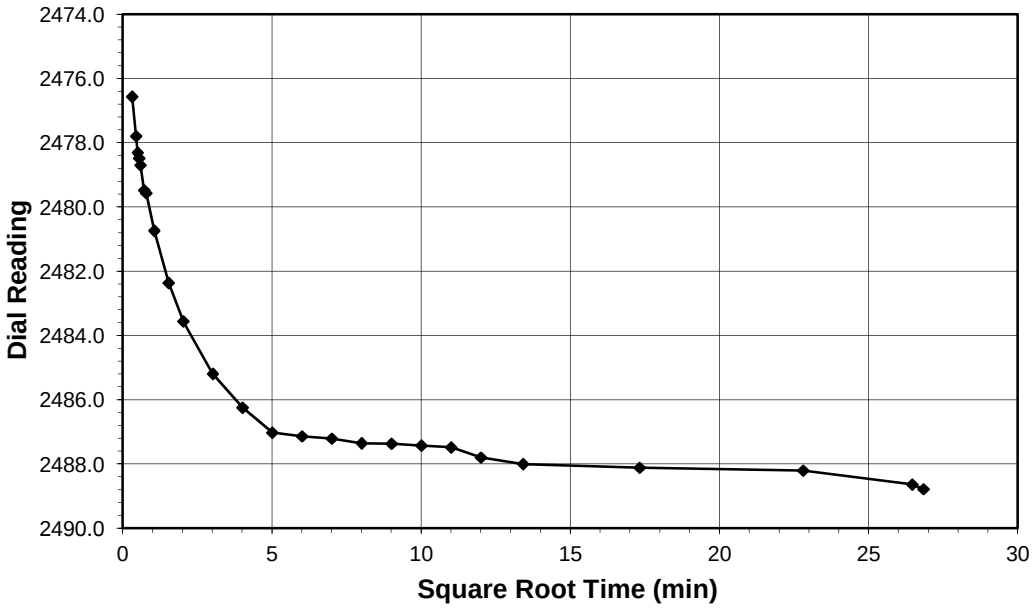
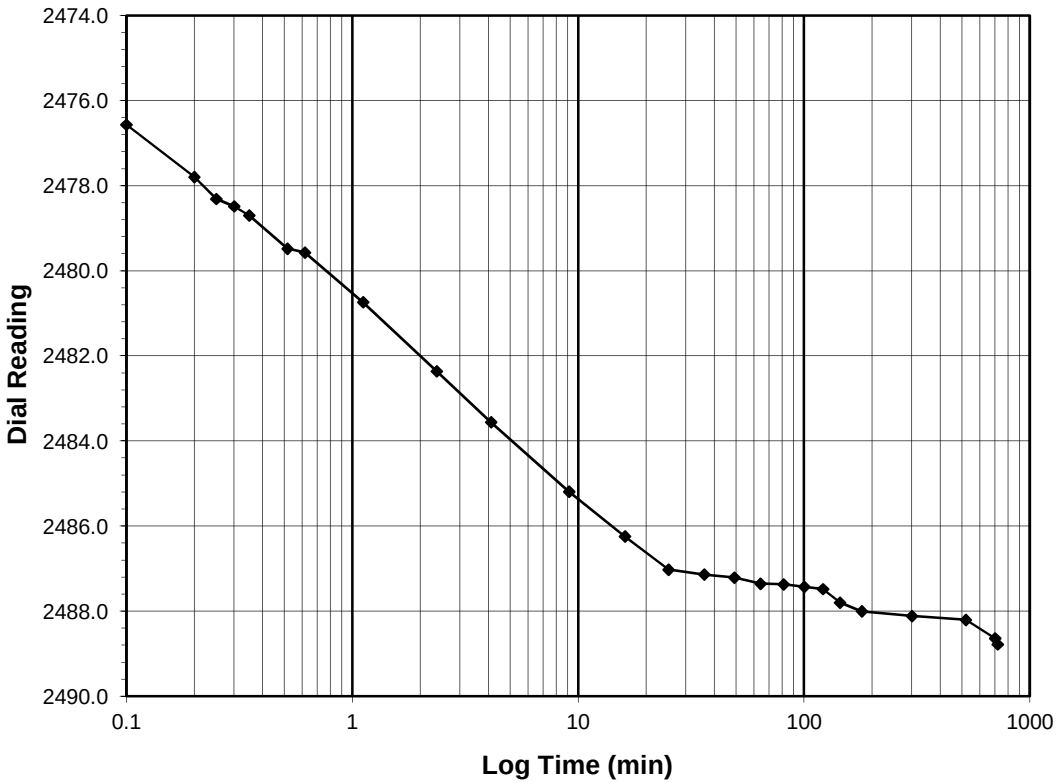
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.25 - 0.5**
Final Reading	**(div)**	**2488.8**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/16/19
Start Time		21:29:39

Elapsed Time (min)	Dial Reading (div)
Initial	**2470.4**
0.10	2476.6
0.20	2477.8
0.25	2478.3
0.30	2478.5
0.35	2478.7
0.52	2479.5
0.62	2479.6
1.12	2480.7
2.37	2482.4
4.12	2483.6
9.12	2485.2
16.12	2486.2
25.12	2487.0
36.12	2487.1
49.12	2487.2
64.12	2487.4
81.13	2487.4
100.13	2487.4
121.13	2487.5
144.13	2487.8
180.13	2488.0
300.13	2488.1
520.13	2488.2
700.13	2488.6
720.08	2488.8

Tested By TM *Date* 5/16/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2

GeoJac-32tsf.xlt

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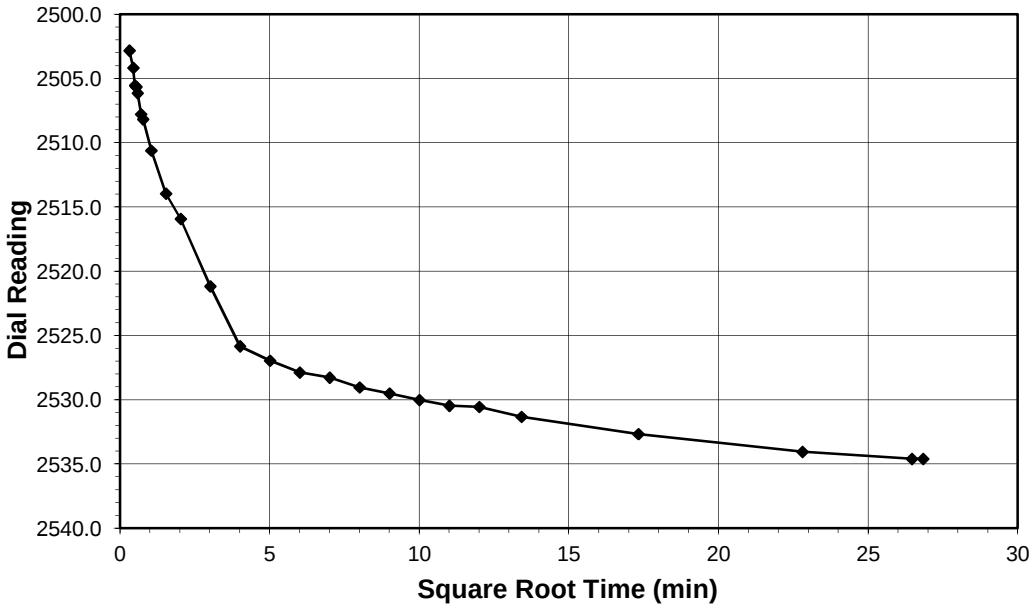
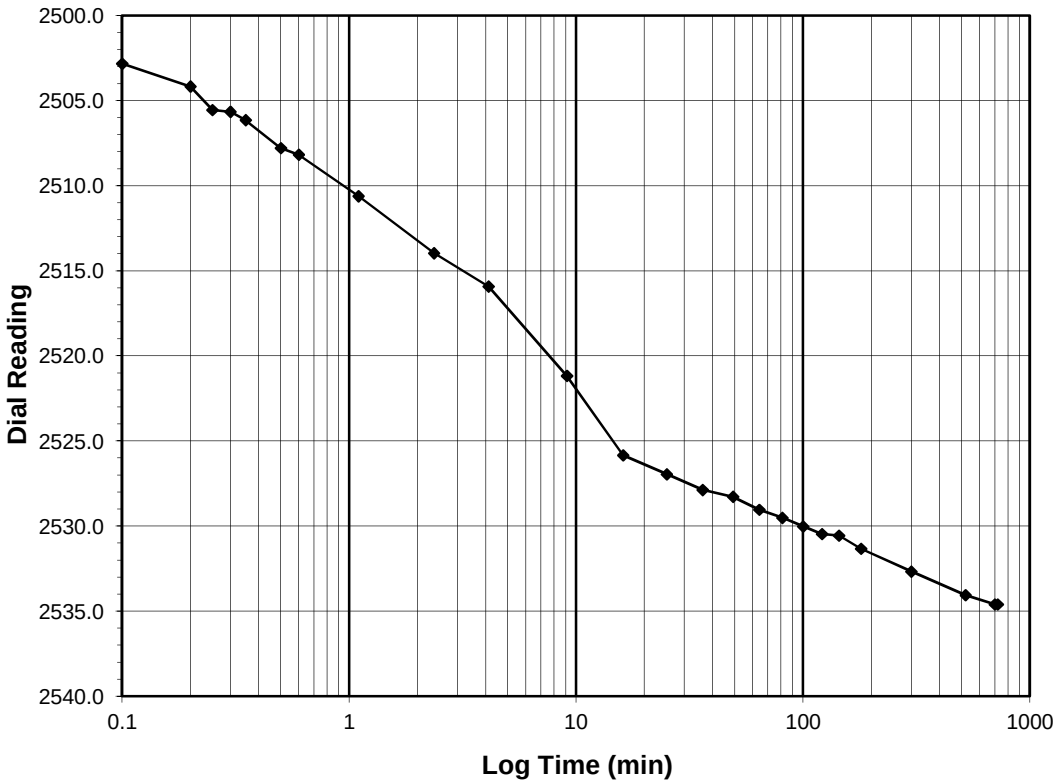
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.5 - 1**
Final Reading	**(div)**	**2534.6**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/17/19
Start Time		9:29:44

Elapsed Time (min)	Dial Reading (div)
Initial	**2488.8**
0.10	2502.8
0.20	2504.2
0.25	2505.6
0.30	2505.7
0.35	2506.1
0.50	2507.8
0.60	2508.2
1.10	2510.6
2.37	2514.0
4.12	2515.9
9.12	2521.2
16.12	2525.8
25.12	2527.0
36.12	2527.9
49.12	2528.3
64.12	2529.0
81.12	2529.5
100.12	2530.0
121.12	2530.5
144.12	2530.6
180.12	2531.3
300.13	2532.7
520.13	2534.1
700.13	2534.6
720.18	2534.6

Tested By *TM* *Date* *5/17/19* *Checked By* *NJM* *Date* *5/23/19*

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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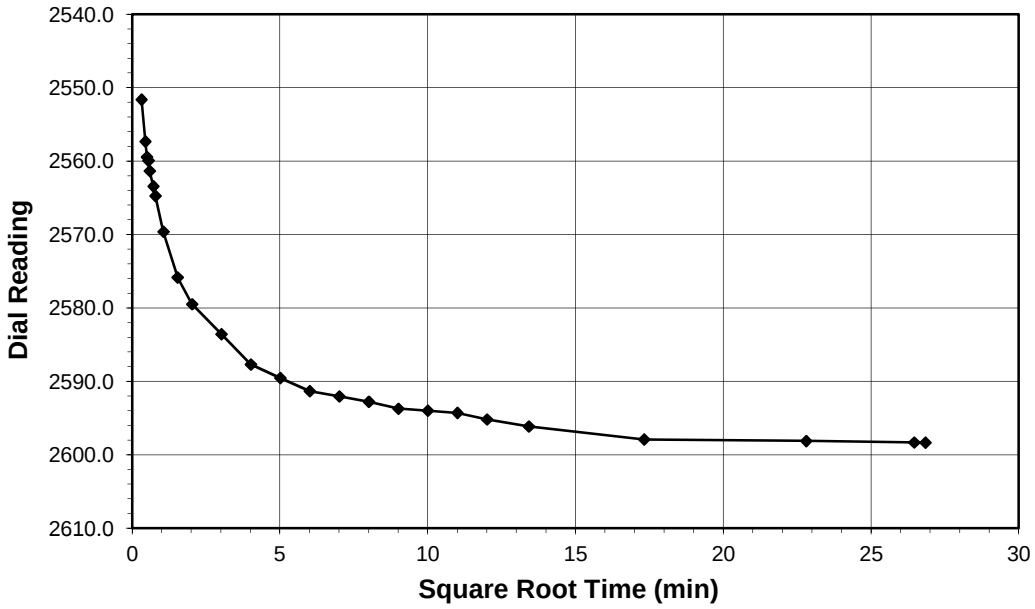
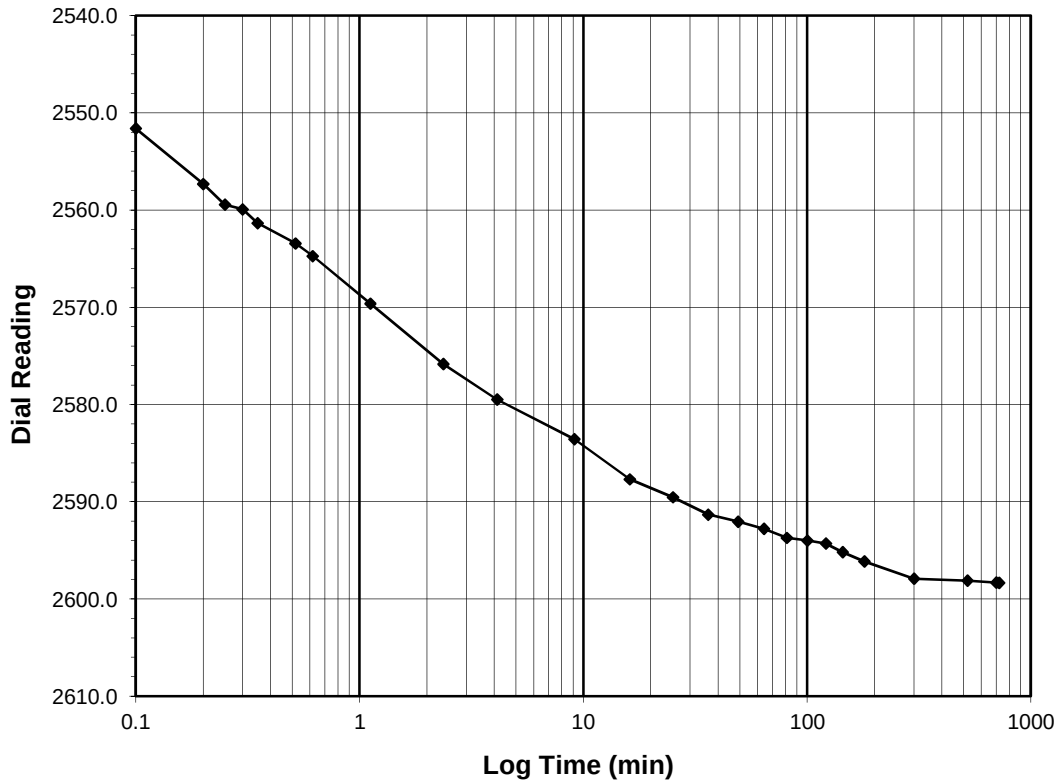
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 2**
Final Reading	**(div)**	**2598.3**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/17/19
Start Time		21:29:55

Elapsed Time (min)	Dial Reading (div)
Initial	**2534.6**
0.10	2551.6
0.20	2557.3
0.25	2559.4
0.30	2559.9
0.35	2561.3
0.52	2563.4
0.62	2564.7
1.12	2569.6
2.37	2575.8
4.12	2579.5
9.12	2583.6
16.12	2587.7
25.12	2589.5
36.12	2591.3
49.12	2592.0
64.12	2592.8
81.12	2593.7
100.12	2594.0
121.12	2594.3
144.12	2595.2
180.12	2596.1
300.12	2597.9
520.12	2598.1
700.12	2598.3
720.40	2598.3

Tested By TM *Date* 5/17/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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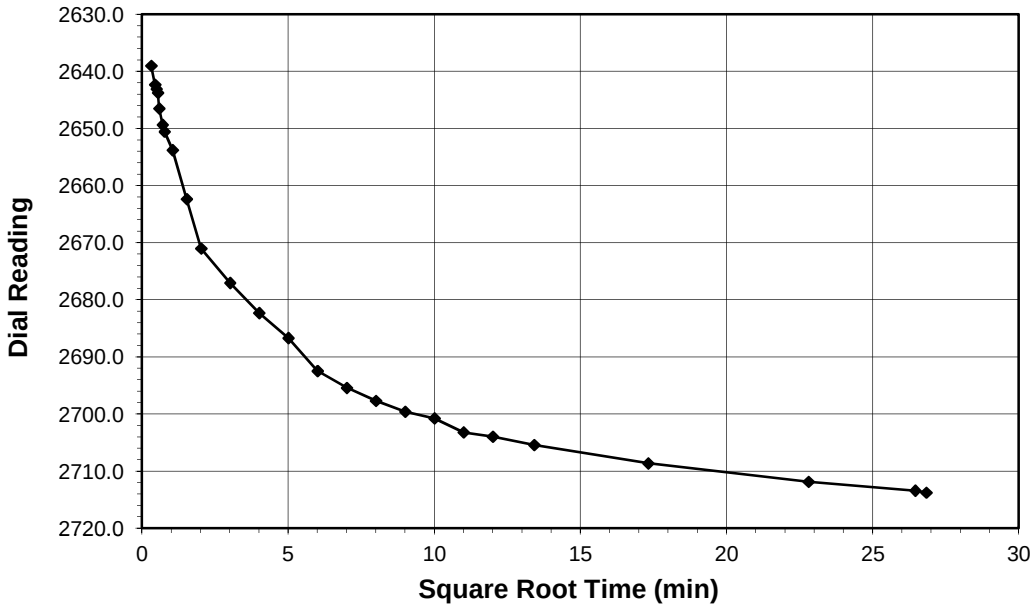
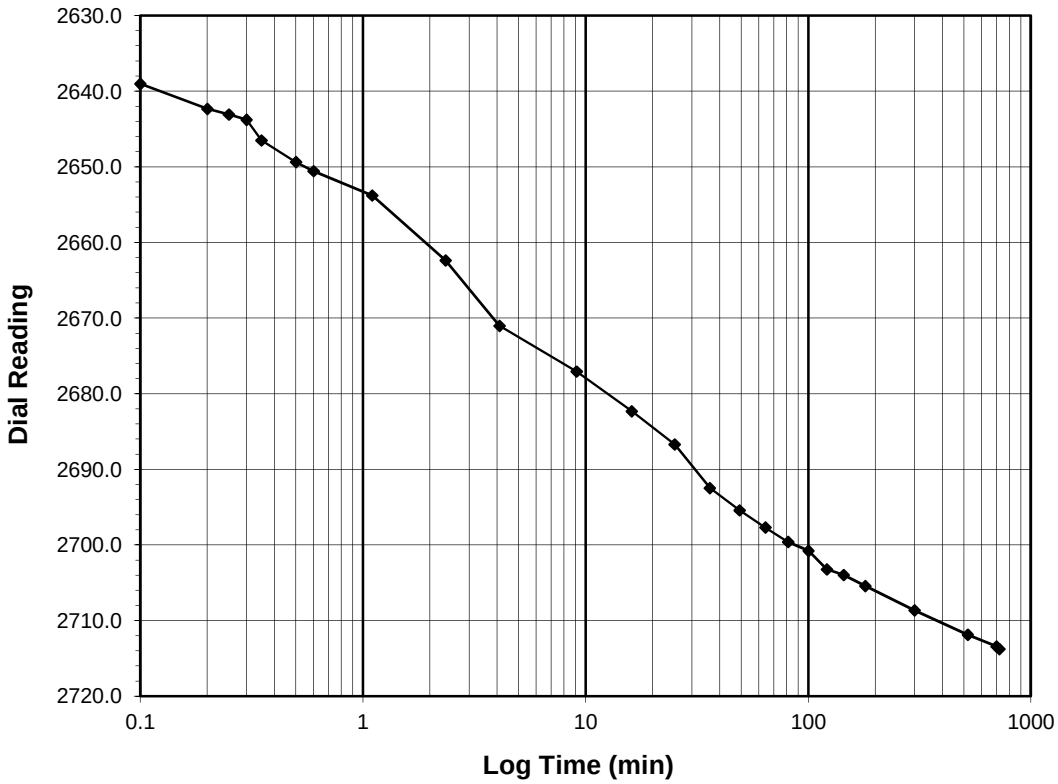
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**2 - 4**
Final Reading	**(div)**	**2713.8**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/18/19
Start Time		9:30:19

Elapsed Time (min)	Dial Reading (div)
Initial	**2598.3**
0.10	2639.0
0.20	2642.3
0.25	2643.1
0.30	2643.8
0.35	2646.5
0.50	2649.4
0.60	2650.6
1.10	2653.8
2.35	2662.4
4.10	2671.0
9.10	2677.1
16.10	2682.3
25.10	2686.7
36.10	2692.5
49.10	2695.4
64.12	2697.7
81.12	2699.6
100.12	2700.8
121.12	2703.2
144.12	2704.0
180.12	2705.4
300.12	2708.6
520.12	2711.9
700.12	2713.4
720.10	2713.8

Tested By TM *Date* 5/18/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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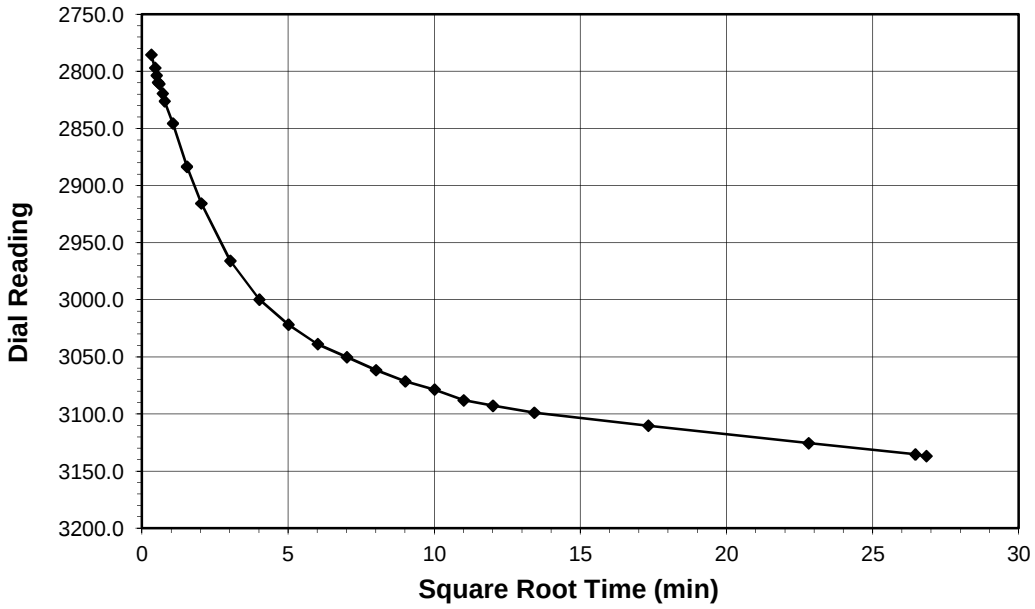
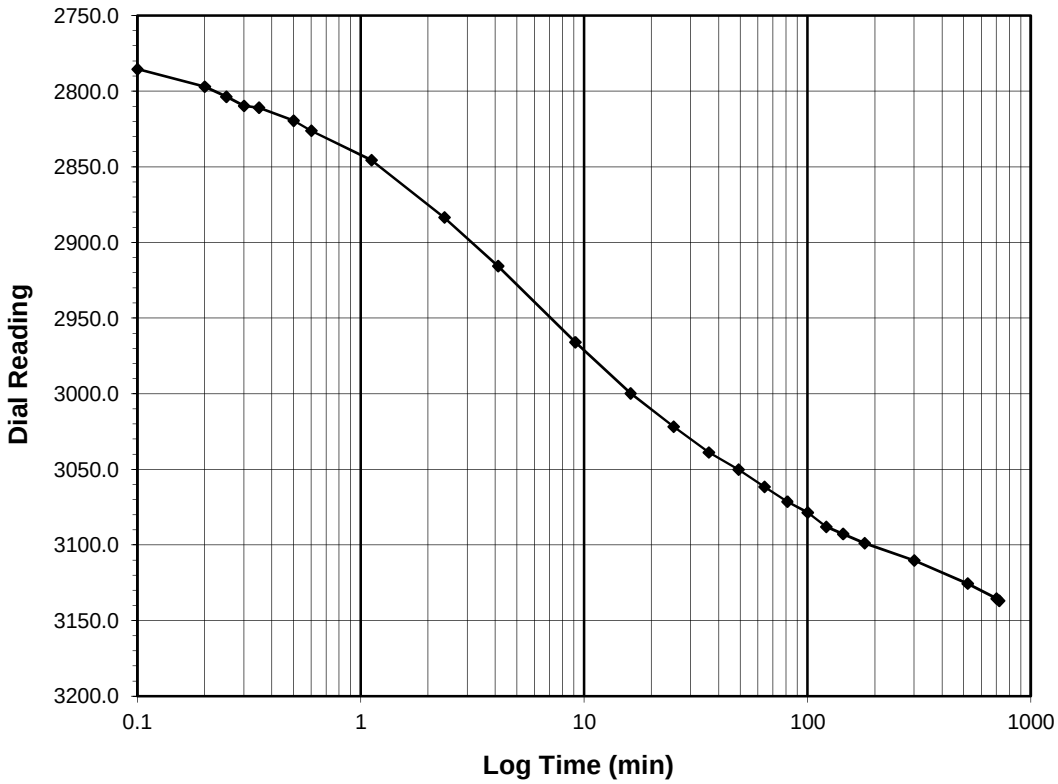
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**4 - 8**
Final Reading	**(div)**	**3136.8**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/18/19
Start Time		21:30:25

Elapsed Time (min)	Dial Reading (div)
Initial	**2713.8**
0.10	2785.4
0.20	2797.0
0.25	2803.6
0.30	2809.7
0.35	2810.9
0.50	2819.4
0.60	2826.1
1.12	2845.6
2.37	2883.4
4.12	2915.6
9.12	2965.9
16.12	2999.7
25.12	3021.8
36.12	3038.8
49.12	3050.2
64.12	3061.6
81.12	3071.4
100.12	3078.6
121.12	3088.0
144.12	3092.7
180.12	3098.8
300.12	3110.3
520.12	3125.5
700.12	3135.4
720.33	3136.8

Tested By TM *Date* 5/18/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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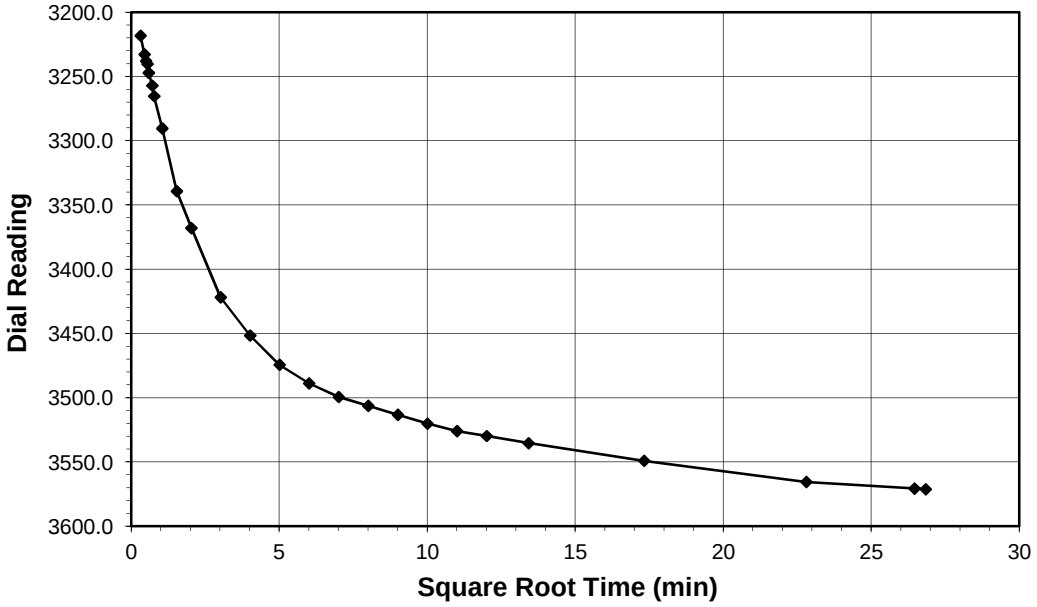
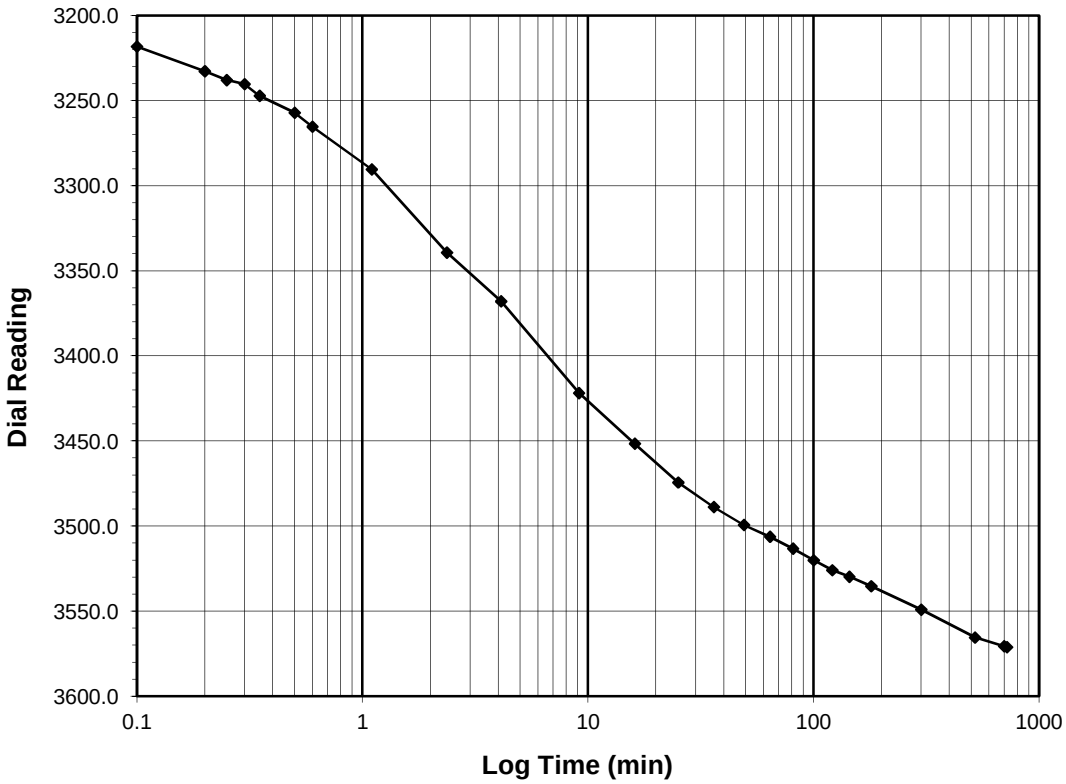
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**8 - 16**
Final Reading	**(div)**	**3571.2**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/19/19
Start Time		9:30:45

Elapsed Time (min)	Dial Reading (div)
Initial	**3136.8**
0.10	3218.2
0.20	3232.7
0.25	3237.9
0.30	3240.2
0.35	3247.1
0.50	3257.0
0.60	3265.3
1.10	3290.4
2.37	3339.2
4.12	3367.9
9.12	3421.8
16.12	3451.5
25.12	3474.4
36.12	3488.8
49.12	3499.4
64.12	3506.3
81.12	3513.3
100.12	3520.1
121.12	3525.9
144.12	3529.7
180.12	3535.3
300.12	3549.1
520.12	3565.5
700.13	3570.6
720.43	3571.2

Tested By TM *Date* 5/19/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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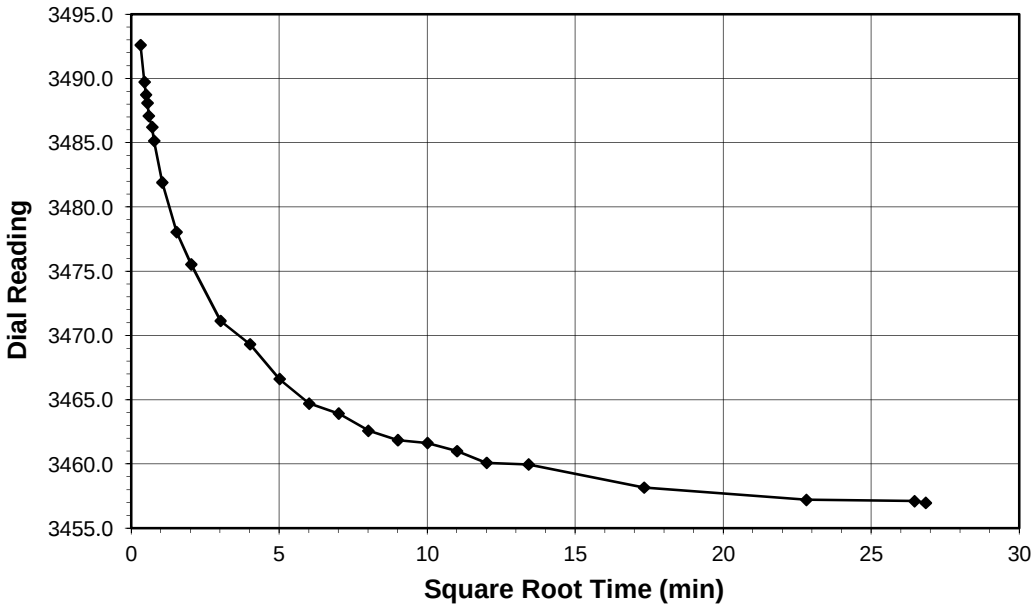
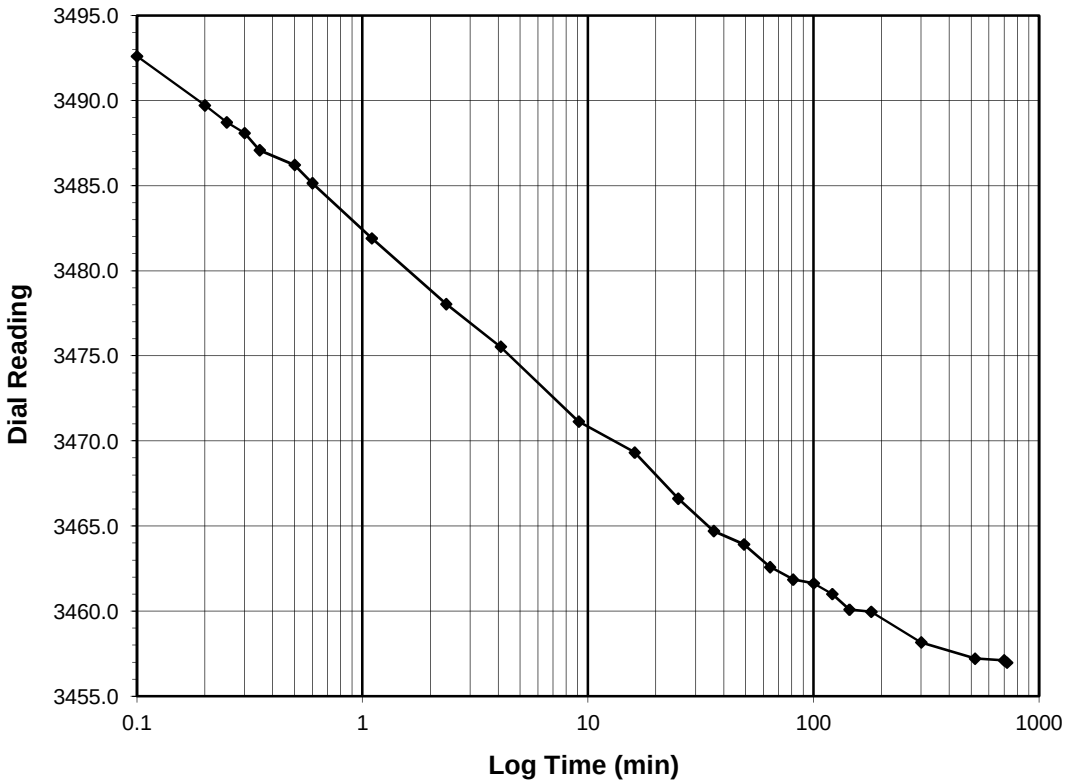
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**16 - 4**
Final Reading	**(div)**	**3457.0**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/19/19
Start Time		21:31:11

Elapsed Time (min)	Dial Reading (div)
Initial	**3571.2**
0.10	3492.6
0.20	3489.7
0.25	3488.7
0.30	3488.1
0.35	3487.1
0.50	3486.2
0.60	3485.2
1.10	3481.9
2.35	3478.0
4.10	3475.5
9.10	3471.1
16.10	3469.3
25.10	3466.6
36.10	3464.7
49.10	3463.9
64.12	3462.6
81.12	3461.9
100.12	3461.6
121.12	3461.0
144.12	3460.1
180.12	3460.0
300.12	3458.2
520.12	3457.2
700.12	3457.1
720.33	3457.0

Tested By *TM* *Date* *5/19/19* *Checked By* *NJM* *Date* *5/23/19*

DCN: CT-24E Date: 8/15/12 Revision: 2

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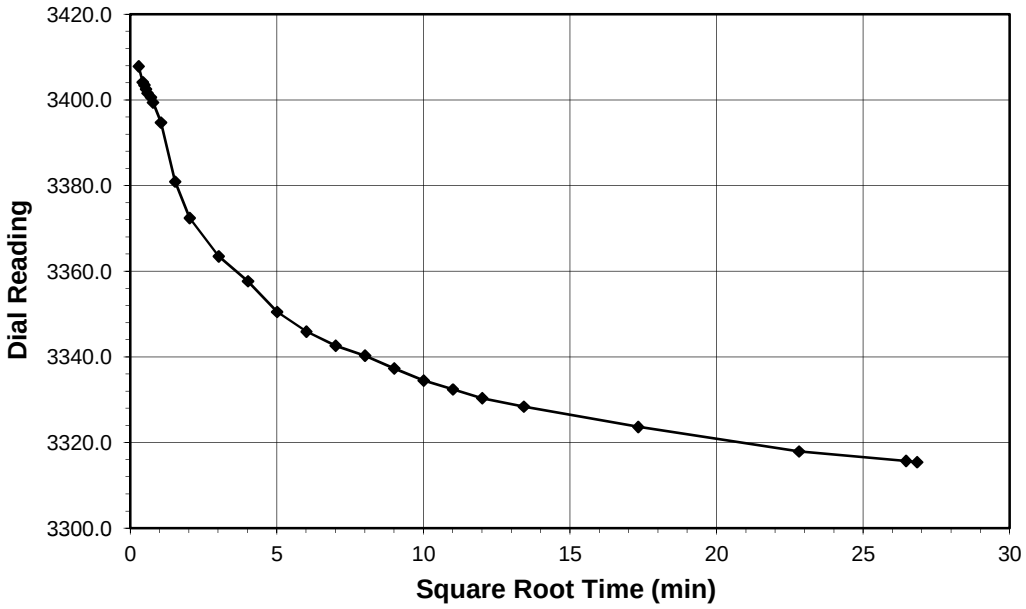
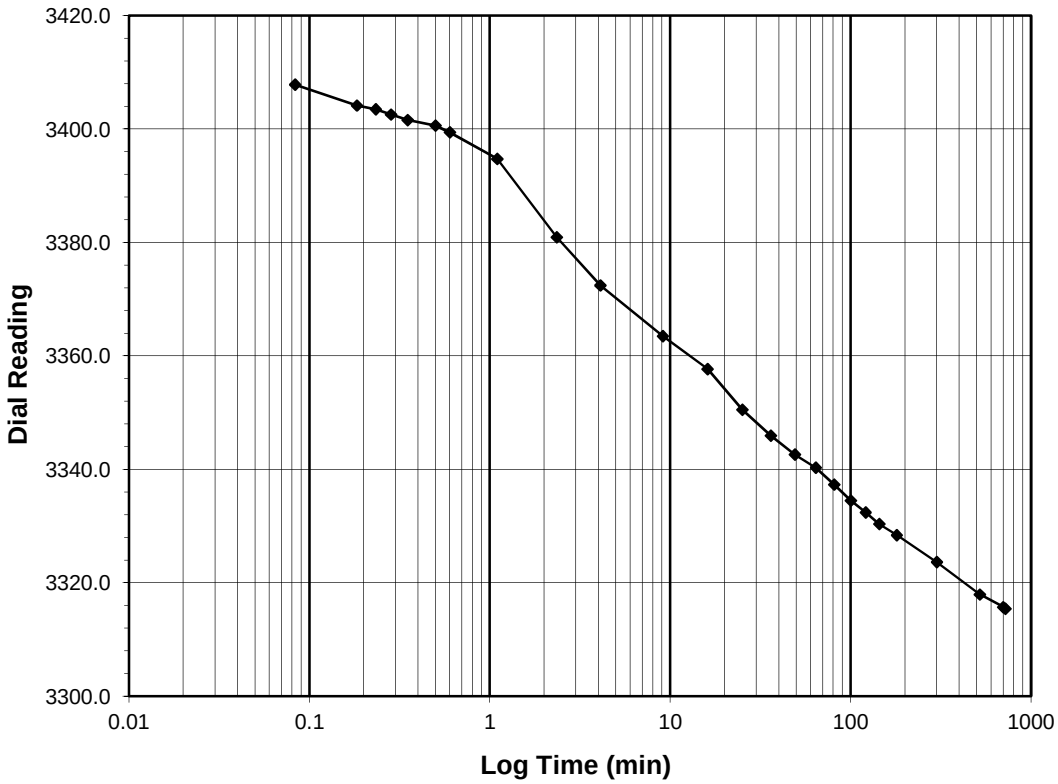
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**4 - 1**
Final Reading	**(div)**	**3315.4**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/20/19
Start Time		9:31:31

Elapsed Time (min)	Dial Reading (div)
Initial	**3457.0**
0.08	3407.8
0.18	3404.1
0.23	3403.5
0.28	3402.6
0.35	3401.6
0.50	3400.6
0.60	3399.4
1.10	3394.7
2.35	3380.9
4.10	3372.4
9.10	3363.5
16.10	3357.7
25.10	3350.5
36.10	3345.9
49.10	3342.6
64.10	3340.3
81.10	3337.3
100.10	3334.5
121.10	3332.4
144.10	3330.4
180.12	3328.4
300.12	3323.7
520.12	3317.9
700.12	3315.7
720.35	3315.4

Tested By TM *Date* 5/20/19 *Checked By* NJM *Date* 5/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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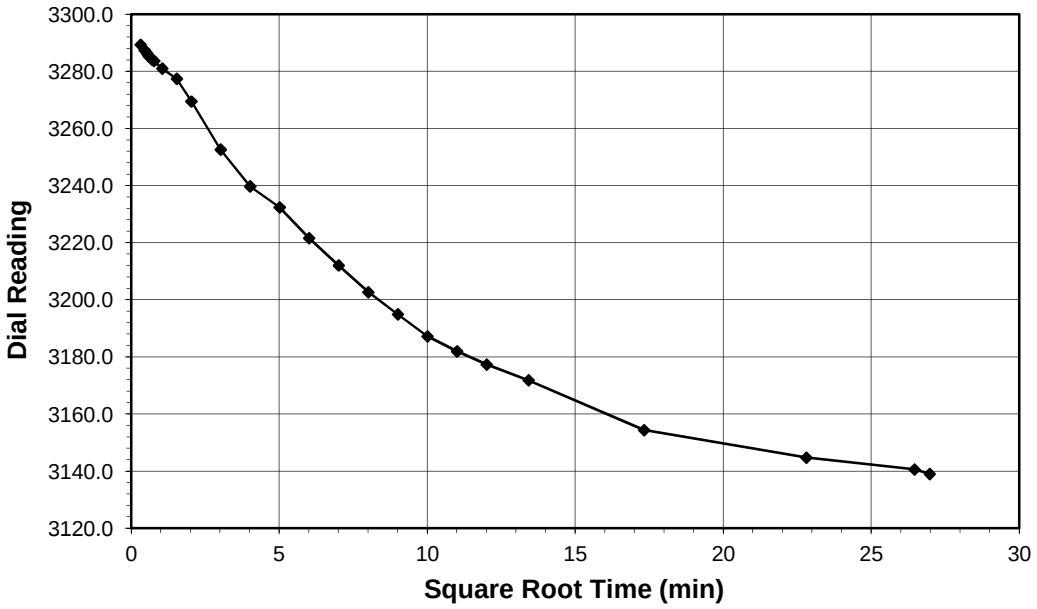
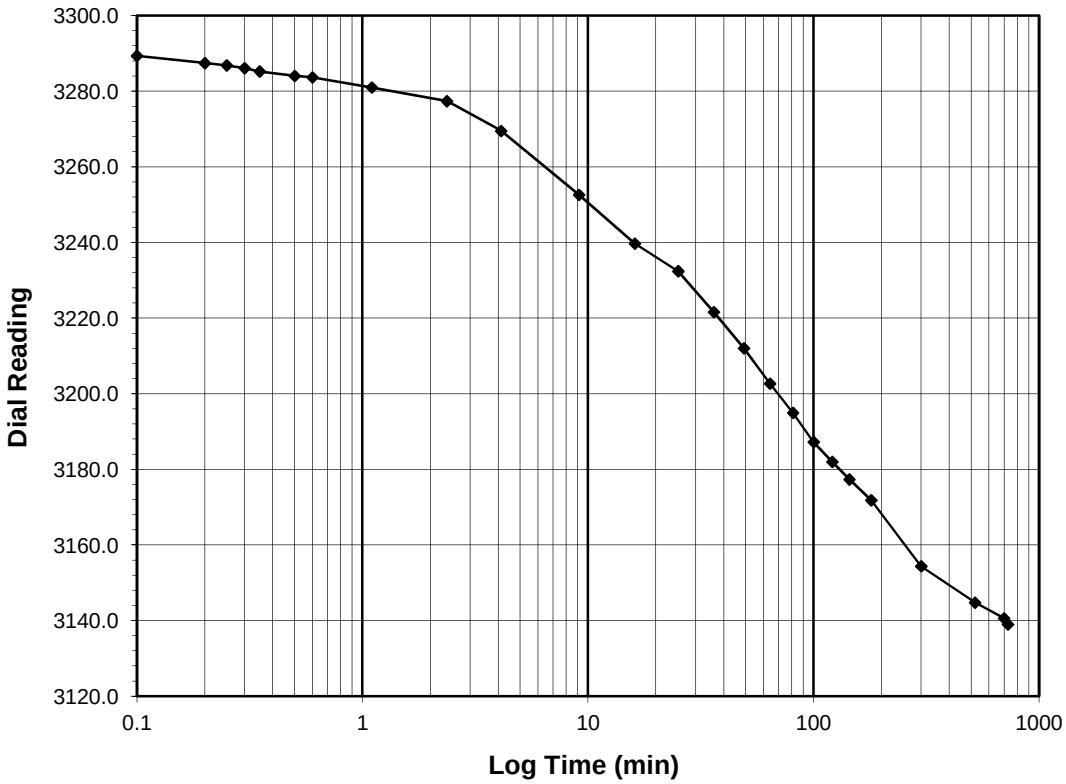
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**1 - 0.25**
Final Reading	**(div)**	**3139.0**
Consolidometer No.		**G1427**
1 Division	(in)	0.0001
Start Date		5/20/19
Start Time		21:31:53

Elapsed Time (min)	Dial Reading (div)
Initial	**3315.4**
0.10	3289.3
0.20	3287.4
0.25	3286.8
0.30	3286.1
0.35	3285.2
0.50	3284.1
0.60	3283.7
1.10	3281.0
2.37	3277.4
4.12	3269.5
9.12	3252.6
16.12	3239.7
25.12	3232.4
36.12	3221.6
49.12	3212.0
64.12	3202.7
81.12	3194.9
100.12	3187.2
121.12	3182.0
144.12	3177.3
180.12	3171.8
300.12	3154.4
520.12	3144.7
700.13	3140.6
727.60	3139.0

Tested By *TM* *Date* *5/20/19* *Checked By* *NJM* *Date* *5/23/19*

DCN: CT-24E Date: 8/15/12 Revision: 2 GeoJac-32tsf.xlt

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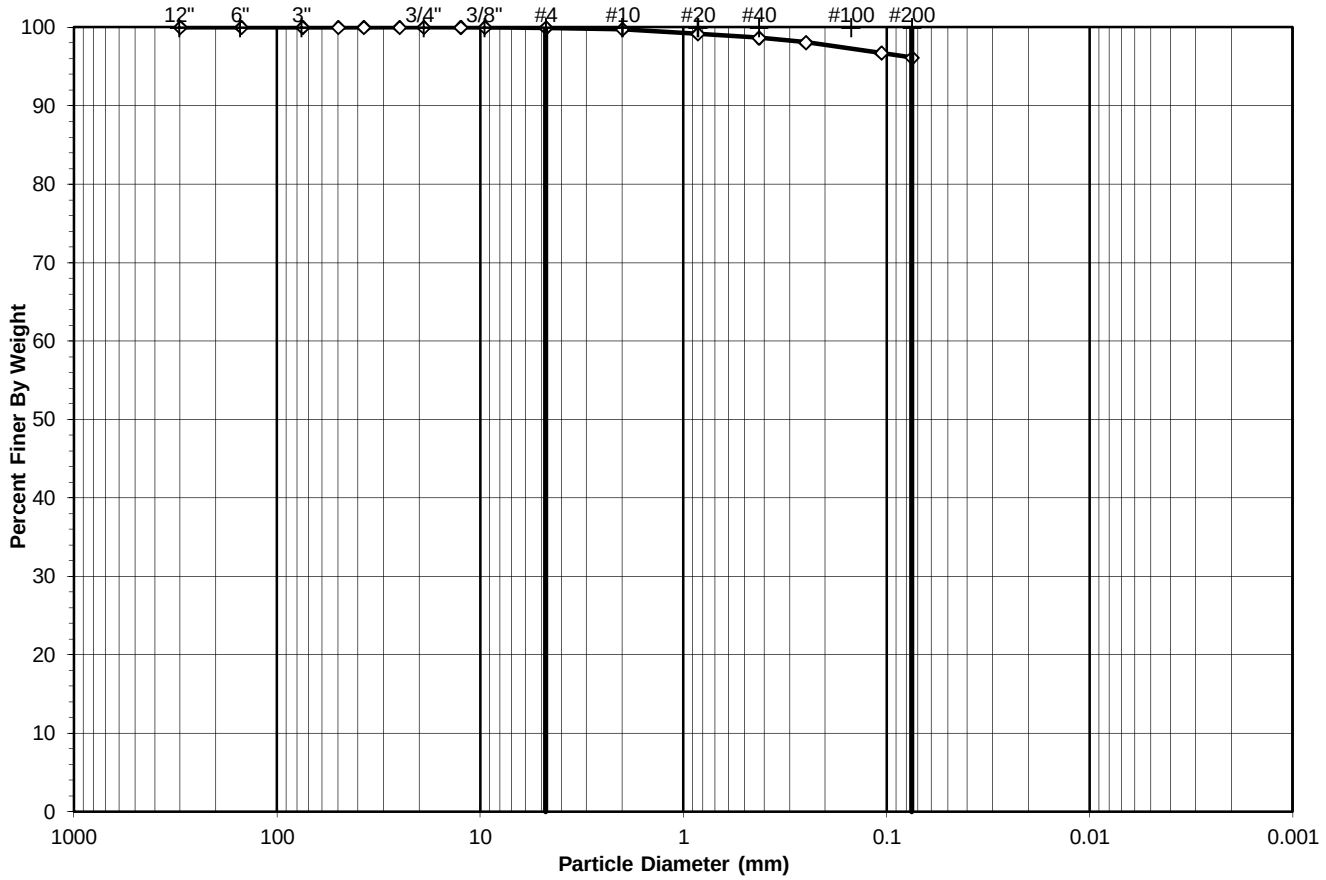
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	20.7-21.2
Project No.:	2019-264-001	Sample No.:	ST-1B
Lab ID:	2019-264-001-005	Soil Color:	Gray

	SIEVE ANALYSIS			*HYDROMETER*	
USCS	**cobbles**	**gravel**	**sand**	**silt and clay fraction**	
USDA	**cobbles**	**gravel**	**sand**	**silt**	**clay**



USCS Summary

Sieve Sizes (mm)		Percentage
Greater Than #4	*Gravel*	0.04
#4 To #200	*Sand*	3.82
Finer Than #200	*Silt & Clay*	96.13

USCS Symbol:

MH, TESTED

USCS Classification:

ELASTIC SILT

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

S:Excel\Excel QA\Spreadsheets\SieveHydJ.xls

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	20.7-21.2
Project No.:	2019-264-001	Sample No.:	ST-1B
Lab ID:	2019-264-001-005	Soil Color:	Gray

Moisture Content of Passing 3/4" Material		Moisture Content of Retained 3/4" Material	
Tare No.:	1536	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	601.24	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	405.94	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	149.31	Weight of Tare (g):	NA
Weight of Water (g):	195.30	Weight of Water (g):	NA
Weight of Dry Soil (g):	256.63	Weight of Dry Soil (g):	NA
Moisture Content (%):	**76.1**	**Moisture Content (%):**	**0.0**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	256.63
Dry Weight of - 3/4" Sample (g):	256.6	Weight of Minus #200 Material (g):	246.71
Wet Weight of +3/4" Sample (g):	0.00	Weight of Plus #200 Material (g):	9.92
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	256.6		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25.0	0.00		0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00		0.00	0.00	100.00	**100.00**
1/2"	12.5	0.00		0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00		0.00	0.00	100.00	**100.00**
#4	4.75	0.11		0.04	0.04	99.96	**99.96**
#10	2.00	0.52		0.20	0.25	99.75	**99.75**
#20	0.85	1.45	(**)	0.57	0.81	99.19	**99.19**
#40	0.425	1.34		0.52	1.33	98.67	**98.67**
#60	0.250	1.49		0.58	1.91	98.09	**98.09**
#140	0.106	3.43		1.34	3.25	96.75	**96.75**
#200	0.075	1.58		0.62	3.87	96.13	**96.13**
Pan	-	246.71		96.13	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Sample*

Tested By HL Date 5/14/19 Checked By KC Date 5/16/19

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

S:Excel\Excel QA\Spreadsheets\SieveHydJ.xls

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Atterberg Limits with Organic Content Test*

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	20.7-21.2
Project No.:	2019-264-001	Sample No.:	ST-1B
Lab ID:	2019-264-001-005	Soil Description:	GRAY ELASTIC SILT

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

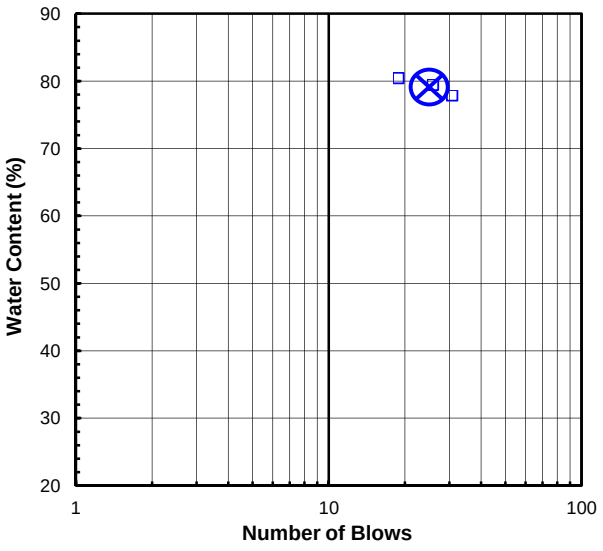
As Received Moisture Content ASTM D2216-10		Liquid Limit Standard Preparation			Liquid Limit *Dried at 110° Prior to Testing		
		1	2	3	4	5	6
Tare Number	1536	540	616	620	12	320	366
Wt. of Tare & Wet Sample (g)	601.24	40.37	39.20	40.06	39.70	41.02	37.33
Wt. of Tare & Dry Sample (g)	405.94	31.64	30.56	31.13	32.73	33.73	30.11
Wt. of Tare (g)	149.31	20.41	19.67	20.01	19.72	20.38	17.10
Wt. of Water (g)	195.3	8.7	8.6	8.9	7.0	7.3	7.2
Wt. of Dry Sample (g)	256.6	11.2	10.9	11.1	13.0	13.4	13.0
Was As Received MC Preserved:	Yes						
Moisture Content (%)	**76.1**	**77.7**	**79.3**	**80.3**	**53.6**	**54.6**	**55.5**
Number of Blows		**31**	**26**	**19**	**32**	**27**	**20**

Plastic Limit Test	1	2	Range
Tare Number	603	1101	
Wt. of Tare & Wet Sample (g)	24.66	24.16	
Wt. of Tare & Dry Sample (g)	23.05	22.52	
Wt. of Tare (g)	18.81	18.20	
Wt. of Water (g)	1.6	1.6	
Wt. of Dry Sample (g)	4.2	4.3	
Moisture Content (%)	**38.0**	**38.0**	**0.0**

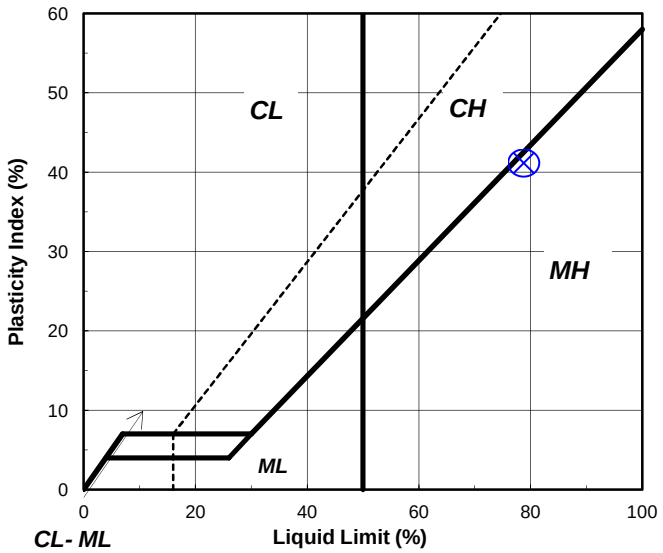
Note: The acceptable range of the two Moisture contents is ± 1.4

Test Results	Standard Prep	*Dried @ 110°
Liquid Limit (%)	**79**	**55**
Plastic Limit (%)	**38**	**N/A**
Plasticity Index (%)	**41**	**N/A**
USCS Symbol	**MH**	**OH**

Flow Curve



Plasticity Chart



Tested By JP *Date* 5/15/19 *Checked By* KC *Date* 5/17/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-001

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	005
Boring No.:	KB19-02
Depth (ft):	20.7-21.2
Sample No.:	ST-1B
Tare Number	A
Weight of Tare & Wet Sample (g)	221.25
Weight of Tare & Dry Sample (g)	167.02
Weight of Tare (g)	95.98
Weight of Water (g)	54.23
Weight of Dry Sample (g)	71.04
Moisture Content	**76.3%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	163.19
Weight of Volatiles (g)	3.83
Weight of Ash (g)	67.21
Ash Content (%)	**94.6%**
Organic Matter (%)	**5.4%**

Tested By SG *Date* 5/14/19 *Checked By* BRB *Date* 5/15/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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ASTM D2488 VISUAL CLASSIFICATION

ASTM D 2488-17

Client	Key Environmental, Inc.
Client Reference	North Landfarm 19819 01 02
Project No.	2019-264-002

Soil descriptions were performed in general accordance with ASTM D2488-17 using the Visual-Manual method. As indicated in Section 1.2.1 of this standard: "When precise classification of soils for engineering purposes is required, the procedures outlined in Test Method D2487 shall be used". Therefore, the information presented herein should be used only as a guide, and not for the establishment of design parameters.

Lab ID	001	002	003	004	005
Boring No.	KB19-01	KB19-01	KB19-01	KB19-01	KB19-02
Depth (ft)	12.0-14-0'	14.0-16.0'	20.0-22.0'	24.0-26.0'	16.0-18.0'
Sample No.	SS03	SS04	SS07	SS09	SS05
			Check All That Apply		
Angular					
Sub-Angular					
Sub-Rounded			X	X	
Rounded				X	
Flat (W/T > 3)					
Elongated (L/W > 3)					
Flat & Elongated					
Color	Gray	Brownish Gray	Dark Brown	Dark Brown	Brownish Gray
Odor - Organic					
Odor - Petroleum			X		
Odor - Other					
Odor - None	X	X		X	X
Dry					
Moist	X	X	X	X	X
Wet					
HCL - None	X	X	X	X	X
HCL - Weak					
HCL - Strong					
Very Soft					
Soft					
Firm	X	X	X	X	X
Hard					
Very Hard					
Cementing - Weak					
Cementing - Moderate					
Cementing - Strong					

ASTM D2488 VISUAL CLASSIFICATION

ASTM D 2488-17

Client	Key Environmental, Inc.
Client Reference	North Landfarm 19819 01 02
Project No.	2019-264-002

Soil descriptions were performed in general accordance with ASTM D2488-17 using the Visual-Manual method. As indicated in Section 1.2.1 of this standard: "When precise classification of soils for engineering purposes is required, the procedures outlined in Test Method D2487 shall be used". Therefore, the information presented herein should be used only as a guide, and not for the establishment of design parameters.

Lab ID	001	002	003	004	005
Boring No.	KB19-01	KB19-01	KB19-01	KB19-01	KB19-02
Depth (ft)	12.0-14-0'	14.0-16.0'	20.0-22.0'	24.0-26.0'	16.0-18.0'
Sample No.	SS03	SS04	SS07	SS09	SS05
Percent Cobbles +3"	0	0	0	0	0
Percent Gravel -3", +#4	0	0	0	0	0
Coarse Gravel -3", +3/4"	0	0	15	0	0
Fine Gravel -3/4", +#4	0	0	0	0	0
Percent Sand -#4, +#200	10	10	20	10	10
Coarse Sand - #4, +#10	0	0	0	0	0
Medium Sand -#10, +#40	0	0	5	0	0
Fine Sand -#40, +#200	10	10	15	10	10
Fines -#200	90	90	80	90	90
Other (Roots, etc.)	0	0	0	0	0
Fine Grained >50% -#200	X	X	X	X	X
Coarse Grained >50% +#200					
Dry Strength					
None					
Low					
Medium					
High	X	X	X	X	X
Very High					
Dilatancy					
None	X	X	X	X	X
Slow					
Rapid					
Toughness					
Low					
Medium	X	X	X	X	X
High					
Non-Plastic					
Low Plasticity					
Medium Plasticity			X	X	X
High Plasticity	X	X			
Classification	Sandy Silty Clay	Sandy Silty Clay	Sandy Silty Clay	Sandy Silty Clay	Sandy Silty Clay

Tested By: *NJM* *Date:* *5/13/19* *Checked By:* *KC* *Date:* 5/13/19

ASTM D2488 VISUAL CLASSIFICATION

ASTM D 2488-17

Client	Key Environmental, Inc.
Client Reference	North Landfarm 19819 01 02
Project No.	2019-264-002

Soil descriptions were performed in general accordance with ASTM D2488-17 using the Visual-Manual method. As indicated in Section 1.2.1 of this standard: "When precise classification of soils for engineering purposes is required, the procedures outlined in Test Method D2487 shall be used". Therefore, the information presented herein should be used only as a guide, and not for the establishment of design parameters.

Lab ID	006	007	008	009	010
Boring No.	KB19-02	KB19-02	KB19-03	KB19-03	KB19-03
Depth (ft)	18.0-20.0'	22.0-24.0'	14.5-15.0'	15.0-16.0'	18.0-20.0'
Sample No.	SS06	SS08	SS04	SS04	SS06
			Check All That Apply		
Angular					
Sub-Angular					
Sub-Rounded			X		
Rounded			X		
Flat (W/T > 3)					
Elongated (L/W > 3)					
Flat & Elongated					
Color	Brownish Gray	Dark Gray	Dark Brown	Brownish Gray	Dark Brown
Odor - Organic					
Odor - Petroleum					
Odor - Other					
Odor - None	X	X	X	X	X
Dry					
Moist	X	X	X	X	X
Wet					
HCL - None	X	X	X	X	X
HCL - Weak					
HCL - Strong					
Very Soft					
Soft					
Firm	X	X	X	X	X
Hard					
Very Hard					
Cementing - Weak					
Cementing - Moderate					
Cementing - Strong					

ASTM D2488 VISUAL CLASSIFICATION

ASTM D 2488-17

Client	Key Environmental, Inc.
Client Reference	North Landfarm 19819 01 02
Project No.	2019-264-002

Soil descriptions were performed in general accordance with ASTM D2488-17 using the Visual-Manual method. As indicated in Section 1.2.1 of this standard: "When precise classification of soils for engineering purposes is required, the procedures outlined in Test Method D2487 shall be used". Therefore, the information presented herein should be used only as a guide, and not for the establishment of design parameters.

Lab ID	006	007	008	009	010
Boring No.	KB19-02	KB19-02	KB19-03	KB19-03	KB19-03
Depth (ft)	18.0-20.0'	22.0-24.0'	14.5-15.0'	15.0-16.0'	18.0-20.0'
Sample No.	SS06	SS08	SS04	SS04	SS06
Percent Cobbles +3"	0	0	0	0	0
Percent Gravel -3", +#4	0	0	0	0	0
Coarse Gravel -3", +3/4"	0	0	0	0	0
Fine Gravel -3/4", +#4	0	0	10	0	0
Percent Sand -#4, +#200	10	10	25	10	10
Coarse Sand - #4, +#10	0	0	0	0	0
Medium Sand -#10, +#40	0	0	15	0	0
Fine Sand -#40, +#200	10	10	10	10	10
Fines -#200	85	85	75	85	85
Other (Roots, etc.)	5 (trace organics)	5 (trace organics)	0	5 (trace organics)	5 (trace organics
Fine Grained >50% -#200	X	X	X	X	X
Coarse Grained >50% +#200					
Dry Strength					
None					
Low					
Medium			X	X	
High	X	X			X
Very High					
Dilatancy					
None	X	X	X	X	X
Slow					
Rapid					
Toughness					
Low					
Medium	X	X	X	X	X
High					
Non-Plastic					
Low Plasticity					
Medium Plasticity	X	X	X		X
High Plasticity				X	
Classification	Sandy Silty Clay, trace Org.	Sandy Silty Clay, trace Org.	Sandy Silty Clay with Gravel	Sandy Silty Clay, trace Org.	Sandy Silty Clay, trace Org

Tested By: NJM *Date:* 5/13/19 *Checked By:* KC *Date:* 5/13/19

ATTERBERG LIMITS

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-04
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-011	Soil Description:	DARK GRAY FAT CLAY

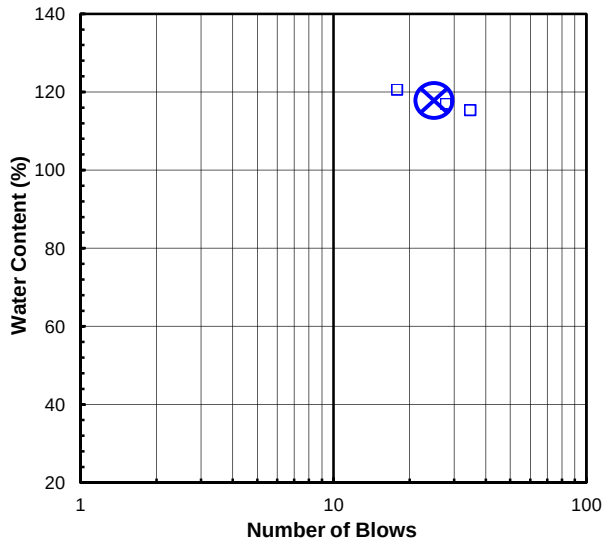
Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Air dried)

As Received Moisture Content		Liquid Limit Test			
ASTM D2216-10		1	2	3	M
Tare Number:	16	3	644	539	U
Wt. of Tare & Wet Sample (g):	69.99	40.64	41.83	43.14	L
Wt. of Tare & Dry Sample (g):	43.01	29.00	29.84	30.75	T
Weight of Tare (g):	8.28	18.89	19.57	20.46	I
Weight of Water (g):	27.0	11.6	12.0	12.4	P
Weight of Dry Sample (g):	34.7	10.1	10.3	10.3	O
Was As Received MC Preserved:	**Yes**				I
Moisture Content (%):	**77.7**	**115.1**	**116.7**	**120.4**	N
Number of Blows:		**35**	**28**	**18**	T

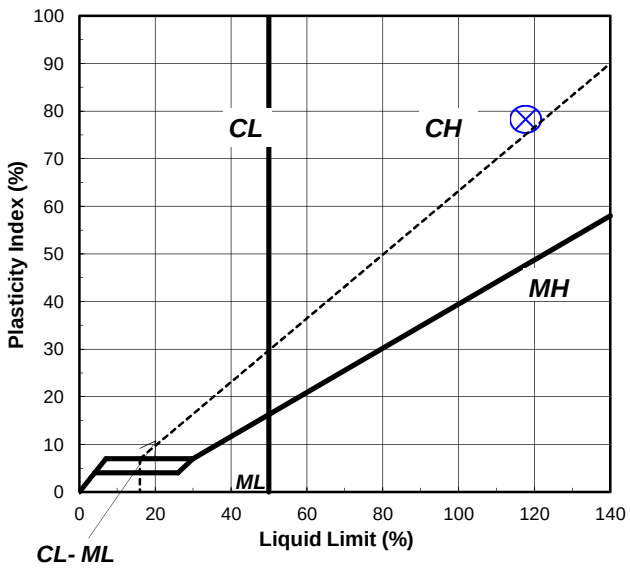
Plastic Limit Test	**1**	**2**	**Range**
Tare Number:	500	325	
Wt. of Tare & Wet Sample (g):	26.57	24.94	
Wt. of Tare & Dry Sample (g):	24.82	23.20	
Weight of Tare (g):	20.39	18.80	
Weight of Water (g):	1.8	1.7	
Weight of Dry Sample (g):	4.4	4.4	
Moisture Content (%):	**39.5**	**39.5**	**0.0**
Note: The acceptable range of the two Moisture Contents is ±			1.4

Test Results	
Liquid Limit (%):	**118**
Plastic Limit (%):	**40**
Plasticity Index (%):	**78**
USCS Symbol:	**CH**

Flow Curve



Plasticity Chart



Tested By TO *Date* 5/13/19 *Checked By* KC *Date* 5/20/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	001
Boring No.:	KB19-01
Depth (ft):	12.0-14.0'
Sample No.:	SS03
Tare Number	X
Weight of Tare & Wet Sample (g)	48.02
Weight of Tare & Dry Sample (g)	36.08
Weight of Tare (g)	19.04
Weight of Water (g)	11.94
Weight of Dry Sample (g)	17.04
Moisture Content	**70.1%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	35.27
Weight of Volatiles (g)	0.81
Weight of Ash (g)	16.23
Ash Content (%)	**95.2%**
Organic Matter (%)	**4.8%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	002
Boring No.:	KB19-01
Depth (ft):	14.0-16.0'
Sample No.:	SS04
Tare Number	16
Weight of Tare & Wet Sample (g)	52.11
Weight of Tare & Dry Sample (g)	36.93
Weight of Tare (g)	18.26
Weight of Water (g)	15.18
Weight of Dry Sample (g)	18.67
Moisture Content	**81.3%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	35.65
Weight of Volatiles (g)	1.28
Weight of Ash (g)	17.39
Ash Content (%)	**93.1%**
Organic Matter (%)	**6.9%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	003
Boring No.:	KB19-01
Depth (ft):	20.0-22.0'
Sample No.:	SS07
Tare Number	C
Weight of Tare & Wet Sample (g)	46.84
Weight of Tare & Dry Sample (g)	34.03
Weight of Tare (g)	19.10
Weight of Water (g)	12.81
Weight of Dry Sample (g)	14.93
Moisture Content	**85.8%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	32.90
Weight of Volatiles (g)	1.13
Weight of Ash (g)	13.80
Ash Content (%)	**92.4%**
Organic Matter (%)	**7.6%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	004
Boring No.:	KB19-01
Depth (ft):	24.0-26.0'
Sample No.:	SS09
Tare Number	P
Weight of Tare & Wet Sample (g)	41.94
Weight of Tare & Dry Sample (g)	30.67
Weight of Tare (g)	18.24
Weight of Water (g)	11.27
Weight of Dry Sample (g)	12.43
Moisture Content	**90.7%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	29.60
Weight of Volatiles (g)	1.07
Weight of Ash (g)	11.36
Ash Content (%)	**91.4%**
Organic Matter (%)	**8.6%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	005
Boring No.:	KB19-02
Depth (ft):	16.0-18.0'
Sample No.:	SS05
Tare Number	S
Weight of Tare & Wet Sample (g)	47.87
Weight of Tare & Dry Sample (g)	30.79
Weight of Tare (g)	18.27
Weight of Water (g)	17.08
Weight of Dry Sample (g)	12.52
Moisture Content	**136.4%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	27.83
Weight of Volatiles (g)	2.96
Weight of Ash (g)	9.56
Ash Content (%)	**76.4%**
Organic Matter (%)	**23.6%**

Tested By *RAL* *Date* *5/10/19* *Checked By* *BRB* *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	006
Boring No.:	KB19-02
Depth (ft):	18.0-20.0'
Sample No.:	SS06
Tare Number	K
Weight of Tare & Wet Sample (g)	49.99
Weight of Tare & Dry Sample (g)	36.19
Weight of Tare (g)	18.52
Weight of Water (g)	13.80
Weight of Dry Sample (g)	17.67
Moisture Content	**78.1%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	34.93
Weight of Volatiles (g)	1.26
Weight of Ash (g)	16.41
Ash Content (%)	**92.9%**
Organic Matter (%)	**7.1%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	007
Boring No.:	KB19-02
Depth (ft):	22.0-24.0'
Sample No.:	SS08
Tare Number	M
Weight of Tare & Wet Sample (g)	49.79
Weight of Tare & Dry Sample (g)	37.70
Weight of Tare (g)	18.47
Weight of Water (g)	12.09
Weight of Dry Sample (g)	19.23
Moisture Content	**62.9%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	36.40
Weight of Volatiles (g)	1.30
Weight of Ash (g)	17.93
Ash Content (%)	**93.2%**
Organic Matter (%)	**6.8%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	008
Boring No.:	KB19-03
Depth (ft):	14.5-15.0'
Sample No.:	SS04
Tare Number	D
Weight of Tare & Wet Sample (g)	63.49
Weight of Tare & Dry Sample (g)	52.84
Weight of Tare (g)	18.23
Weight of Water (g)	10.65
Weight of Dry Sample (g)	34.61
Moisture Content	**30.8%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	51.94
Weight of Volatiles (g)	0.90
Weight of Ash (g)	33.71
Ash Content (%)	**97.4%**
Organic Matter (%)	**2.6%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	009
Boring No.:	KB19-03
Depth (ft):	15.0-16.0'
Sample No.:	SS04
Tare Number	J
Weight of Tare & Wet Sample (g)	58.19
Weight of Tare & Dry Sample (g)	40.73
Weight of Tare (g)	19.44
Weight of Water (g)	17.46
Weight of Dry Sample (g)	21.29
Moisture Content	**82.0%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	39.09
Weight of Volatiles (g)	1.64
Weight of Ash (g)	19.65
Ash Content (%)	**92.3%**
Organic Matter (%)	**7.7%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	010
Boring No.:	KB19-03
Depth (ft):	18.0-20.0'
Sample No.:	SS06
Tare Number	H
Weight of Tare & Wet Sample (g)	48.06
Weight of Tare & Dry Sample (g)	33.22
Weight of Tare (g)	17.81
Weight of Water (g)	14.84
Weight of Dry Sample (g)	15.41
Moisture Content	**96.3%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	31.83
Weight of Volatiles (g)	1.39
Weight of Ash (g)	14.02
Ash Content (%)	**91.0%**
Organic Matter (%)	**9.0%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

\\GEOSERVER\Data Drive\2019 GEOTECHNICAL PROJECTS\Key Environmental, Inc\2019-264-002 North Landfarm 19819\[2019-264-002-010 LOI.xls]Sheet1

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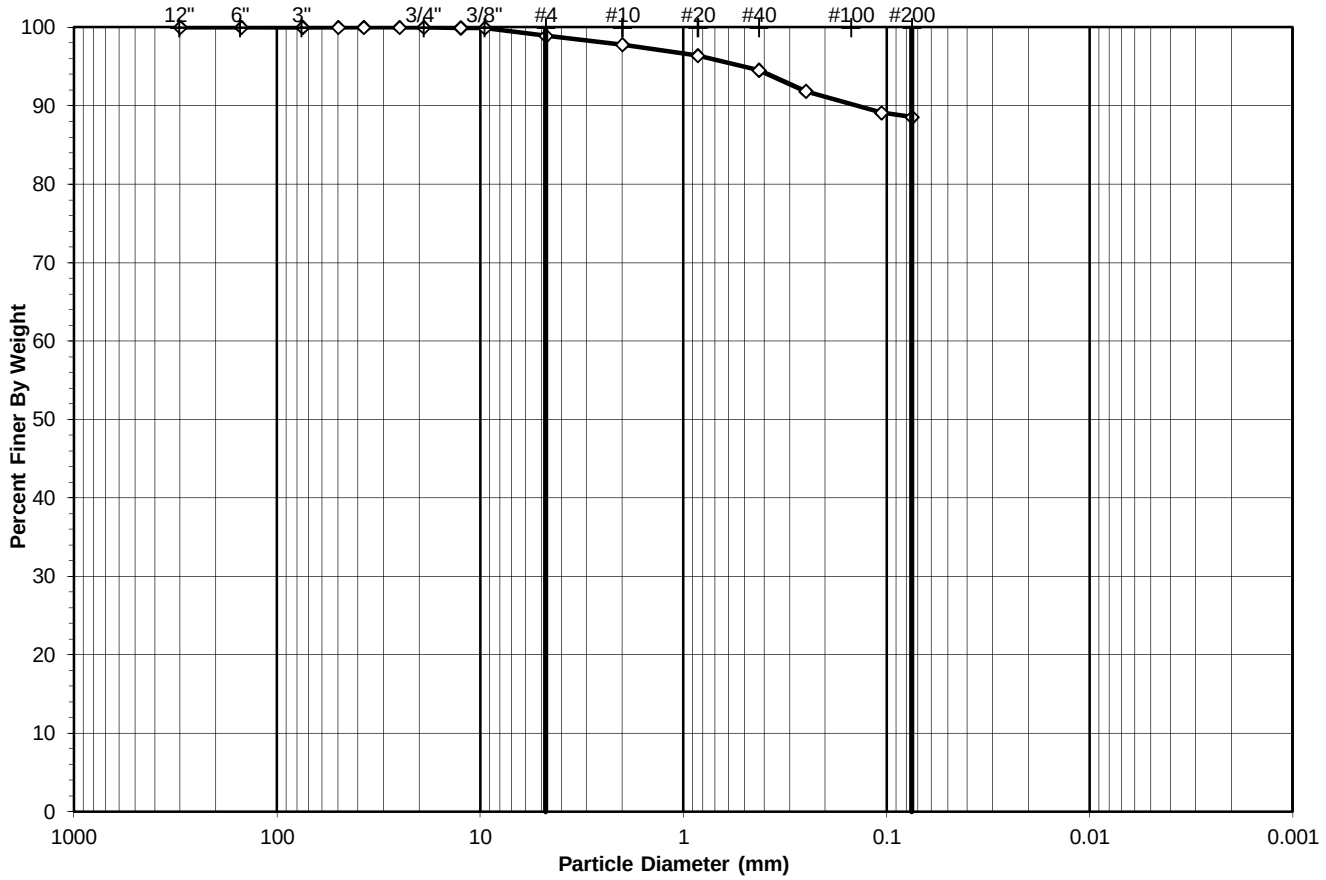
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-04
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-011	Soil Color:	Dark Gray

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



USCS Summary

Sieve Sizes (mm)		Percentage
Greater Than #4	*Gravel*	1.10
#4 To #200	*Sand*	10.35
Finer Than #200	*Silt & Clay*	88.55

USCS Symbol:
CH, TESTED

USCS Classification:
FAT CLAY

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

S:Excel\Excel QA\Spreadsheets\SieveHydJ.xls

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-04
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-011	Soil Color:	Dark Gray

Moisture Content of Passing 3/4" Material		Moisture Content of Retained 3/4" Material	
Tare No.:	20	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	464.65	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	346.29	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	201.09	Weight of Tare (g):	NA
Weight of Water (g):	118.36	Weight of Water (g):	NA
Weight of Dry Soil (g):	145.20	Weight of Dry Soil (g):	NA
Moisture Content (%):	**81.5**	**Moisture Content (%):**	**0.0**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	145.20
Dry Weight of - 3/4" Sample (g):	145.2	Weight of Minus #200 Material (g):	128.58
Wet Weight of +3/4" Sample (g):	0.00	Weight of Plus #200 Material (g):	16.62
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	145.2		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25.0	0.00		0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00		0.00	0.00	100.00	**100.00**
1/2"	12.5	0.07		0.05	0.05	99.95	**99.95**
3/8"	9.50	0.05		0.03	0.08	99.92	**99.92**
#4	4.75	1.47		1.01	1.10	98.90	**98.90**
#10	2.00	1.58		1.09	2.18	97.82	**97.82**
#20	0.85	2.04	(**)	1.40	3.59	96.41	**96.41**
#40	0.425	2.69		1.85	5.44	94.56	**94.56**
#60	0.250	3.90		2.69	8.13	91.87	**91.87**
#140	0.106	4.01		2.76	10.89	89.11	**89.11**
#200	0.075	0.81		0.56	11.45	88.55	**88.55**
Pan	-	128.58		88.55	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Sample*

Tested By HL Date 5/13/19 Checked By KC Date 5/20/19

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

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Atterberg Limits with Organic Content Test*

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-04
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-011	Soil Description:	DARK GRAY FAT CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

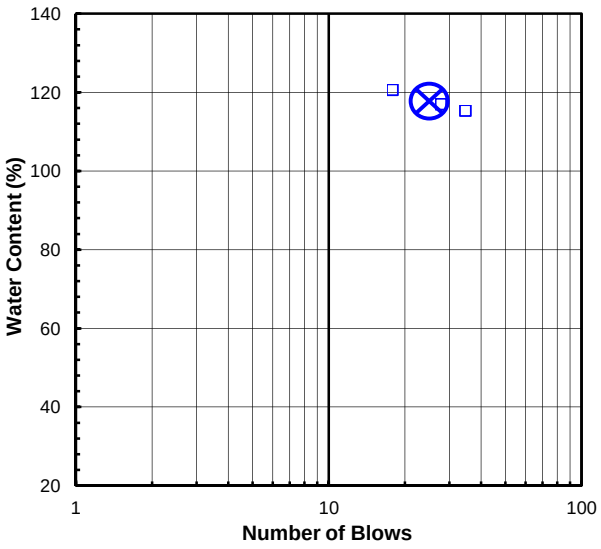
As Received Moisture Content ASTM D2216-10		Liquid Limit Standard Preparation			Liquid Limit *Dried at 110° Prior to Testing		
		1	2	3	4	5	6
Tare Number	16	3	644	539	131	357	235
Wt. of Tare & Wet Sample (g)	69.99	40.64	41.83	43.14	40.46	36.14	35.09
Wt. of Tare & Dry Sample (g)	43.01	29.00	29.84	30.75	32.78	30.24	28.82
Wt. of Tare (g)	8.28	18.89	19.57	20.46	19.70	20.47	18.75
Wt. of Water (g)	27.0	11.6	12.0	12.4	7.7	5.9	6.3
Wt. of Dry Sample (g)	34.7	10.1	10.3	10.3	13.1	9.8	10.1
Was As Received MC Preserved:	Yes						
Moisture Content (%)	**77.7**	**115.1**	**116.7**	**120.4**	**58.7**	**60.4**	**62.3**
Number of Blows		**35**	**28**	**18**	**34**	**23**	**16**

Plastic Limit Test	1	2	Range
Tare Number	500	325	
Wt. of Tare & Wet Sample (g)	26.57	24.94	
Wt. of Tare & Dry Sample (g)	24.82	23.20	
Wt. of Tare (g)	20.39	18.80	
Wt. of Water (g)	1.8	1.7	
Wt. of Dry Sample (g)	4.4	4.4	
Moisture Content (%)	**39.5**	**39.5**	**0.0**

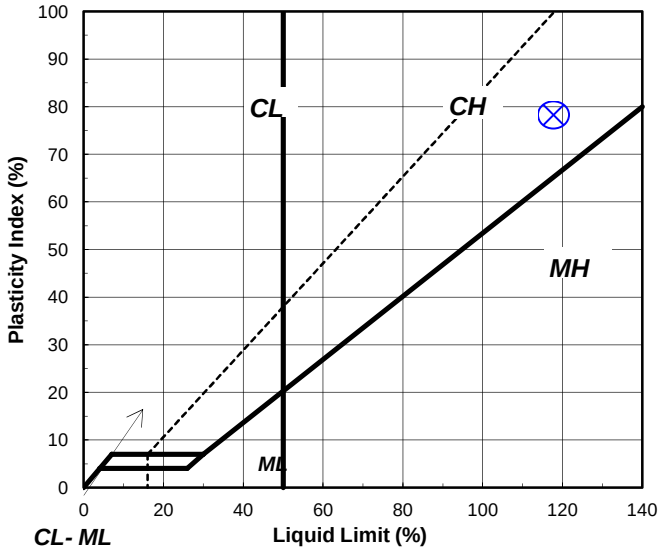
Note: The acceptable range of the two Moisture contents is ± 1.4

Test Results	Standard Prep	*Dried @ 110°
Liquid Limit (%)	**118**	**60**
Plastic Limit (%)	**40**	**N/A**
Plasticity Index (%)	**78**	**N/A**
USCS Symbol	**CH**	**OH**

Flow Curve



Plasticity Chart



Tested By TO *Date* 5/17/19 *Checked By* KC *Date* 5/20/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	011
Boring No.:	KB19-04
Depth (ft):	16.0-22.0'
Sample No.:	SS05, 06 & 07
Tare Number	12
Weight of Tare & Wet Sample (g)	52.29
Weight of Tare & Dry Sample (g)	37.75
Weight of Tare (g)	18.90
Weight of Water (g)	14.54
Weight of Dry Sample (g)	18.85
Moisture Content	**77.1%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	36.60
Weight of Volatiles (g)	1.15
Weight of Ash (g)	17.70
Ash Content (%)	**93.9%**
Organic Matter (%)	**6.1%**

Tested By RAL *Date* 5/10/19 *Checked By* BRB *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

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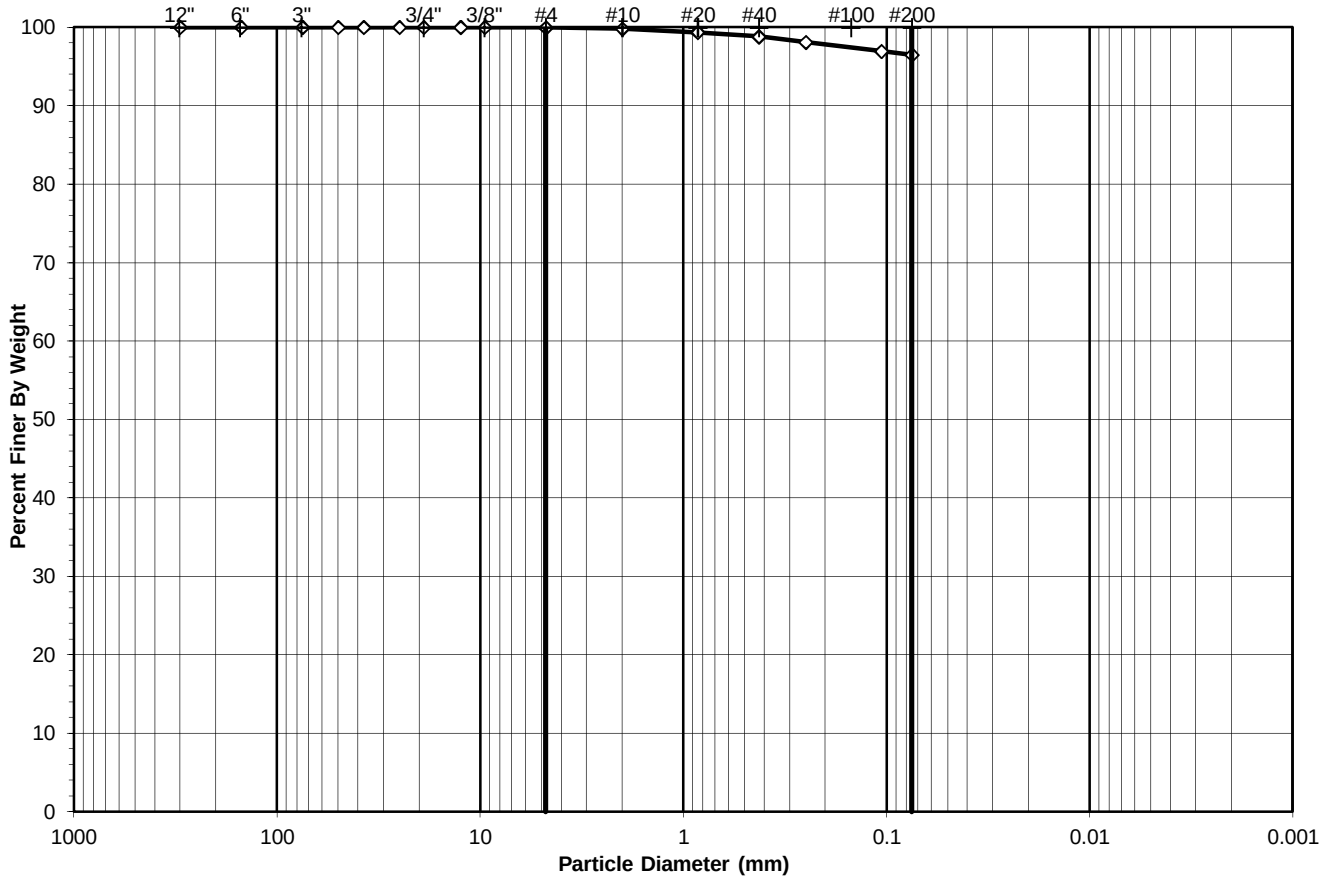
SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-05
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-012	Soil Color:	Dark Gray Clay

	SIEVE ANALYSIS			HYDROMETER	
USCS	cobbles	gravel	sand	silt and clay fraction	
USDA	cobbles	gravel	sand	silt	clay



USCS Summary

Sieve Sizes (mm)		Percentage
Greater Than #4	*Gravel*	0.04
#4 To #200	*Sand*	3.45
Finer Than #200	*Silt & Clay*	96.52

USCS Symbol:
CH, TESTED

USCS Classification:
FAT CLAY

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

S:Excel\Excel QA\Spreadsheets\SieveHydJ.xls

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WASH SIEVE ANALYSIS

ASTM D 422-63 (2007)

Client:	Key Environmental, Inc.	Boring No.:	KB19-05
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-012	Soil Color:	Dark Gray Clay

Moisture Content of Passing 3/4" Material		Moisture Content of Retained 3/4" Material	
Tare No.:	58	Tare No.:	NA
Wt. of Tare & Wet Sample (g):	473.96	Weight of Tare & Wet Sample (g):	NA
Wt. of Tare & Dry Sample (g):	348.57	Weight of Tare & Dry Sample (g):	NA
Weight of Tare (g):	197.05	Weight of Tare (g):	NA
Weight of Water (g):	125.39	Weight of Water (g):	NA
Weight of Dry Soil (g):	151.52	Weight of Dry Soil (g):	NA
Moisture Content (%):	**82.8**	**Moisture Content (%):**	**0.0**

Wet Weight of -3/4" Sample (g):	NA	Weight of the Dry Sample (g):	151.52
Dry Weight of - 3/4" Sample (g):	151.5	Weight of Minus #200 Material (g):	146.24
Wet Weight of +3/4" Sample (g):	0.00	Weight of Plus #200 Material (g):	5.28
Dry Weight of + 3/4" Sample (g):	0.00		
Total Dry Weight of Sample (g):	151.5		

Sieve Size	Sieve Opening (mm)	Weight of Soil Retained (g)		Percent Retained (%)	Accumulated Percent Retained (%)	Percent Finer (%)	**Accumulated Percent Finer (%)**
12"	300	0.00		0.00	0.00	100.00	**100.00**
6"	150	0.00		0.00	0.00	100.00	**100.00**
3"	75	0.00		0.00	0.00	100.00	**100.00**
2"	50	0.00	(*)	0.00	0.00	100.00	**100.00**
1 1/2"	37.5	0.00		0.00	0.00	100.00	**100.00**
1"	25.0	0.00		0.00	0.00	100.00	**100.00**
3/4"	19.0	0.00		0.00	0.00	100.00	**100.00**
1/2"	12.5	0.00		0.00	0.00	100.00	**100.00**
3/8"	9.50	0.00		0.00	0.00	100.00	**100.00**
#4	4.75	0.06		0.04	0.04	99.96	**99.96**
#10	2.00	0.21		0.14	0.18	99.82	**99.82**
#20	0.85	0.66	(**)	0.44	0.61	99.39	**99.39**
#40	0.425	0.86		0.57	1.18	98.82	**98.82**
#60	0.250	1.07		0.71	1.89	98.11	**98.11**
#140	0.106	1.76		1.16	3.05	96.95	**96.95**
#200	0.075	0.66		0.44	3.48	96.52	**96.52**
Pan	-	146.24		96.52	100.00	-	**-**

Notes : *(*) The + 3/4" sieve analysis is based on the Total Dry Weight of the Sample*
*(**) The - 3/4" sieve analysis is based on the Weight of the Dry Sample*

Tested By HL Date 5/13/19 Checked By KC Date 5/14/19

DCN: CT-S3B, DATE: 7/17/17, REVISION: 9e

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Atterberg Limits with Organic Content Test*

ASTM D 4318-17

Client:	Key Environmental, Inc.	Boring No.:	KB19-05
Client Reference:	North Landfarm 19819 01 02	Depth (ft):	16.0-22.0'
Project No.:	2019-264-002	Sample No.:	SS05, 06 & 07
Lab ID:	2019-264-002-012	Soil Description:	DARK GRAY FAT CLAY

Note: The USCS symbol used with this test refers only to the minus No. 40 sieve material. See the "Sieve and Hydrometer Analysis" graph page for the complete material description. (Minus No. 40 sieve material, Airdried)

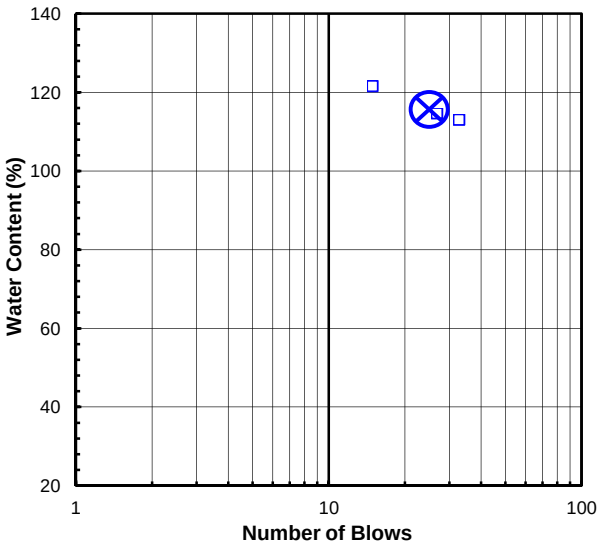
As Received Moisture Content ASTM D2216-10		Liquid Limit Standard Preparation			Liquid Limit *Dried at 110° Prior to Testing		
		1	2	3	4	5	6
Tare Number	33	396	203	319	641	640	642
Wt. of Tare & Wet Sample (g)	52.07	38.51	41.29	41.58	40.74	40.51	40.49
Wt. of Tare & Dry Sample (g)	31.80	27.48	29.57	28.80	32.84	32.68	32.71
Wt. of Tare (g)	8.35	17.70	19.33	18.27	19.29	19.56	19.97
Wt. of Water (g)	20.3	11.0	11.7	12.8	7.9	7.8	7.8
Wt. of Dry Sample (g)	23.5	9.8	10.2	10.5	13.6	13.1	12.7
Was As Received MC Preserved:	Yes						
Moisture Content (%)	**86.4**	**112.8**	**114.5**	**121.4**	**58.3**	**59.7**	**61.1**
Number of Blows		**33**	**27**	**15**	**33**	**24**	**19**

Plastic Limit Test	1	2	Range
Tare Number	2289	1265	
Wt. of Tare & Wet Sample (g)	26.76	23.92	
Wt. of Tare & Dry Sample (g)	24.91	22.14	
Wt. of Tare (g)	20.42	17.75	
Wt. of Water (g)	1.9	1.8	
Wt. of Dry Sample (g)	4.5	4.4	
Moisture Content (%)	**41.2**	**40.5**	**0.7**

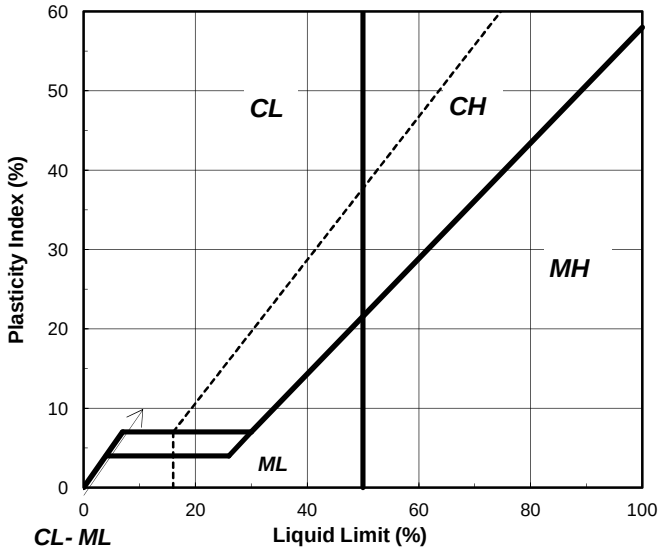
Note: The acceptable range of the two Moisture contents is ± 1.4

Test Results	Standard Prep	*Dried @ 110°
Liquid Limit (%)	**116**	**60**
Plastic Limit (%)	**41**	**N/A**
Plasticity Index (%)	**75**	**N/A**
USCS Symbol	**CH**	**OH**

Flow Curve



Plasticity Chart



Tested By	*TO*	*Date*	*5/13/19*	*Checked By*	*KC*	*Date*	5/14/19

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Moisture, Ash, and Organic Matter (Loss on Ignition)

ASTM D 2974-14

Client:	Key Environmental, Inc.
Client Reference:	North Landfarm 19819 01 02
Project No.:	2019-264-002

Method B (To 0.1%)

Moisture Content

ASTM D2216

Lab ID:	012
Boring No.:	KB19-05
Depth (ft):	16.0-22.0'
Sample No.:	SS05, 06 & 07
Tare Number	I
Weight of Tare & Wet Sample (g)	64.37
Weight of Tare & Dry Sample (g)	44.69
Weight of Tare (g)	18.97
Weight of Water (g)	19.68
Weight of Dry Sample (g)	25.72
Moisture Content	**76.5%**

Method C

Ash Content, Organic Matter

Furnace Temperature (°C)	440
Weight of Tare & Ash (g)	43.23
Weight of Volatiles (g)	1.46
Weight of Ash (g)	24.26
Ash Content (%)	**94.3%**
Organic Matter (%)	**5.7%**

Tested By *RAL* *Date* *5/10/19* *Checked By* *BRB* *Date* 5/13/19

DCN: CT-S8, REV: 4e, DATE: 4/18/17

\\GEOSERVER\Data Drive\2019 GEOTECHNICAL PROJECTS\Key Environmental, Inc\2019-264-002 North Landfarm 19819\[2019-264-002-012 LOI.xls]Sheet1

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APPENDIX C

Boring Logs

BOREHOLE LOG: KB19-01

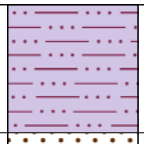
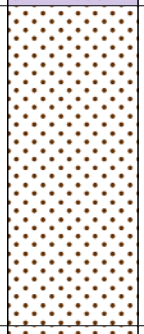
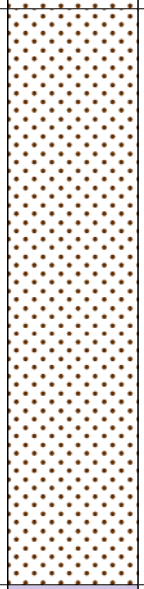
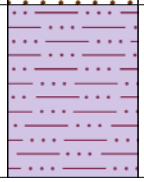
DATE DRILLED: 4/23/19 to 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.82
NORTHING (ft): 630459.33
EASTING (ft): 563620.17
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 32.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
0	Fill		Dark brown to brown SILTY FM SAND fill, little c sand and gravel, wet.	Hand Auger NA	Hand Auger NA	0	Fill 0-11.75 ft-bgs
	Fill		Dark brown to brown FM SAND fill, some silt, little c sand and gravel, wet.			>100	
5	Fill		Dark brown to brown FM SAND fill, some c sand, and gravel, little silt, wet at 0.5 ft-bgs.			0	
				SS-01 (1.6)	6 6 7		

NOTES:

Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 6 ft at 230 degrees from KB19-01 (N 630453.77 E 563615.39 EL 9.96 ft).

BOREHOLE LOG: KB19-01

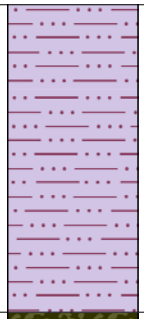
DATE DRILLED: 4/23/19 to 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.82
NORTHING (ft): 630459.33
EASTING (ft): 563620.17
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 32.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
10	Fill		Brown SILTY FM SAND fill, trace gravel and red stone/brick fragments, wet.		5	0	
				SS-02 (1.8)	8		
					6		
					3		
					4		Top of PEAT 11.75 ft-bgs
				SS-03 (0.55)	4		
					2		
					1		
					1		
				SS-04 (1.0)	1		
15					1		Acker 2" Vane and 12" Lower Force Arm ASTM D2573 Vane Shear Test at 14.5 ft-bgs Peak: 200 in-lbs, 1034 psf Remolded: 100 in-lbs, 517 psf Tube Sample (ST1) 15-17.3 ft-bgs Recovery 2.3/2.3 ft
					1		
					1		
				SS-05 (1.05)	1		
					1		
					1		
					1		

NOTES:

Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 6 ft at 230 degrees from KB19-01 (N 630453.77 E 563615.39 EL 9.96 ft).

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-01

DATE DRILLED: 4/23/19 to 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.82
NORTHING (ft): 630459.33
EASTING (ft): 563620.17
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 32.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
20	Pt		Black to greenish gray Silty PEAT, little organics, trace f sand, some rock fragments at 21 ft-bgs, moist.	SS-06 (1.3)	1 1 1	<10	
				SS-07 (0.7)	1 1 1 1		
				SS-08 (1.8)	1 1 1 2		
25				SS-09 (0.8)	1 1 1 1		
				SS-10 (0.9)	1 1 1 1		

NOTES:

Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 6 ft at 230 degrees from KB19-01 (N 630453.77 E 563615.39 EL 9.96 ft).

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-01

DATE DRILLED: 4/23/19 to 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.82
NORTHING (ft): 630459.33
EASTING (ft): 563620.17
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 32.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
				SS-11 (2.0)	1		
					2		Top of SAND 29 ft-bgs
					6		
					10		
30	SP		Gray FM SAND, some c sand, little gravel, trace silt.	SS-12 (2.0)	6	0	
					13		
					15		
					17		End of Boring - 32 ft-bgs

NOTES:

Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 6 ft at 230 degrees from KB19-01 (N 630453.77 E 563615.39 EL 9.96 ft).

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-02

DATE DRILLED: 4/24/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.52
NORTHING (ft): 630489.78
EASTING (ft): 563649.48
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 30.0
WATER LEVEL DURING DRILLING (ft-bgs): 4.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
0	Fill		Brown SILTY FMC SAND fill with some gravel, moist.			0	
	Fill		Dark brown to black FMC SAND fill with some silt and gravel, moist.	Hand Auger NA	Hand Auger NA	>100	
	Fill		Black SILTY CLAY fill, moist.			<10	
	Fill		Gray FMC SAND fill, some gravel, wet at.4.5 ft-bgs.			0	
	Fill		Black SILTY CLAY fill, moist.			<10	
5							Fill 0-15 ft-bgs
				SS-01 (2.0)	1 2 3		

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5 ft at 315 degrees from KB19-02 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-02

DATE DRILLED: 4/24/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.52
NORTHING (ft): 630489.78
EASTING (ft): 563649.48
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 30.0
WATER LEVEL DURING DRILLING (ft-bgs): 4.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
10	Fill		Gray to brown FMC SAND fill, some gravel, wet.		3	0	
				SS-02 (0.9)	2		
					1		
					3		
					3		
				SS-03 (1.3)	4		
					4		
					4		
					4		
				SS-04 (1.2)	2		
15					3		Top of PEAT 15 ft-bgs
					1		
					1		
				SS-05 (1.05)	1		
					2		
					1		
					1		
					1		Acker 2" Vane and 12" Lower

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5 ft at 315 degrees from KB19-02 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-02

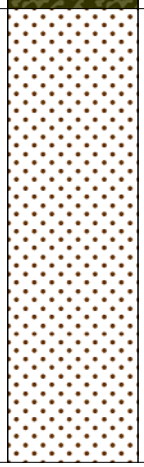
DATE DRILLED: 4/24/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.52
NORTHING (ft): 630489.78
EASTING (ft): 563649.48
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 30.0
WATER LEVEL DURING DRILLING (ft-bgs): 4.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
20	Pt		Black to greenish gray Silty PEAT, little organics, trace f sand, some gravel fragments at 19 ft-bgs, moist.	SS-06 (2.0)	2 2 1	<10	Force Arm ASTM D2573 Vane Shear Test at 18.5 ft-bgs Peak: 350 in-lbs, 1810 psf Remolded: 200 in-lbs, 1034 psf Tube Sample (ST1) 19-21.3 ft-bgs Recovery 2.3/2.3 ft
				SS-07 (1.8)	2 2 2 1		
				SS-08 (1.95)	1 1 1 2		
					3		
25	SP		Gray FMC SAND, little gravel, trace silt, wet.	SS-09 (1.9)	3 2 2	0	Top of SAND 24.5 ft-bgs
				SS-10 (1.1)	2 3 4 4		

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5 ft at 315 degrees from KB19-02 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-02

DATE DRILLED: 4/24/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.52
NORTHING (ft): 630489.78
EASTING (ft): 563649.48
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 30.0
WATER LEVEL DURING DRILLING (ft-bgs): 4.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
30				SS-11 (2.0)	9 13 16 18		End of Boring - 30 ft-bgs

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5 ft at 315 degrees from KB19-02 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-03

DATE DRILLED: 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 8.36
NORTHING (ft): 630394.69
EASTING (ft): 563607.45
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 26.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
0	Fill		Brown, SILTY FM SAND fill, some c sand and gravel, wet at 0.5 ft-bgs.			0	
	Fill		Black SILTY CLAY fill, moist.			<10	
5	Fill		No Recovery	Hand Auger NA	Hand Auger NA		Fill 0-11.5 ft-bgs
				SS-01 (1.0)	4 15 7		

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5.5 ft at 328 degrees from KB19-03 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-03

DATE DRILLED: 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 8.36
NORTHING (ft): 630394.69
EASTING (ft): 563607.45
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 26.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
10	Fill		Brown FM SAND fill, with little c. sand and gravel, trace silt, wet.		8	0	
				SS-02 (1.6)	1		
					1		
					1		Top of PEAT 11.5 ft-bgs
					1		
				SS-03 (1.4)	1		
					1		
					1		
					1		
15				SS-04 (1.9)	1		
					1		
					1		
					1		
				SS-05 (1.1)	1		
					1		
					1		
	Pt		Black to greenish gray Silty PEAT, little organics, trace f sand, some gravel fragments at 19 ft-bgs, moist.		1	<10	Acker 2" Vane and 12" Lower Force Arm ASTM D2573 Vane Shear Test at 17.5 ft-bgs Peak: 175 in-lbs, 905 psf Remolded: 100 in-lbs, 517 psf
					1		

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5.5 ft at 328 degrees from KB19-03 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-03

DATE DRILLED: 4/25/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 8.36
NORTHING (ft): 630394.69
EASTING (ft): 563607.45
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough, Oscar Argueta, and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 26.0
WATER LEVEL DURING DRILLING (ft-bgs): 0.5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
20				SS-06 (2.0)	1		Tube Sample (ST1) 18-20 ft-bgs
					1		Recovery 1.9/1.9 ft
					1		
				SS-07 (1.8)	1		
					1		
					1		
					1		
				SS-08 (2.0)	1		
					2		
					4		
					7		Top of SAND 23.75 ft-bgs
25	SP		Gray FM SAND, some c. sand, little silt and gravel, wet.	SS-09 (1.5)	8	0	
					13		
					17		
					15		End of Boring - 26 ft-bgs

NOTES:
Top 8 ft cleared with air knife/hand auger. Vane Shear test and Thin-walled tube sample completed in offset boring approx. 5.5 ft at 328 degrees from KB19-03 (N 630492.66 E 563645.00, EL 10.23 ft). Bentonite drilling mud used to keep borehole from collapsing.

BOREHOLE LOG: KB19-04

DATE DRILLED: 4/26/19

PROJECT INFORMATION	DRILLING INFORMATION
PROJECT: Buckeye/Hess Terminal North Landfarm	DRILLING CO: Unitech Drilling
SITE LOCATION: Port Reading, NJ	DRILLER: Bob Hough and Oscar Argueta
PROJECT NO: 19819-01-02	DRILLING RIG: CME 55 Track Rig 390115
KEY FIELD GEOLOGIST: Philip Griffith	DRILLING METHOD: HSA (4.25" ID)
GROUND SURFACE ELEVATION (ft): 10.43	SAMPLING METHOD: ASTM D1586 SPT
NORTHING (ft): 630507.83	HAMMER TYPE: Auto Hammer
EASTING (ft): 563576.17	TOTAL BORING DEPTH (ft-bgs): 28.0
DATUM: NJSPCS NAD83, NAVD88	WATER LEVEL DURING DRILLING (ft-bgs): 5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
0	Fill		Gravel fill.	Hand Auger NA	Hand Auger NA	0	Fill 0-14 ft-bgs
	Fill		Brown, orange, and red FM sand fill, some c sand and gravel, moist.			0	
	Fill		Black SILTY CLAY fill, moist.			<10	
	Fill		Brown, orange, and red FM sand fill, some c sand and gravel, moist to wet at 5 ft-bgs.			0	
5	Fill		Brown FM SAND fill, with some c. sand and gravel, wet. Gravel increases with depth.	SS-01 (0.8)	1	0	
					1		
					2		
					4		
				SS-02 (0.9)	6		
					5		
					4		

NOTES:

Top 6 ft cleared with air knife/hand auger. Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-04

DATE DRILLED: 4/26/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 10.43
NORTHING (ft): 630507.83
EASTING (ft): 563576.17
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough and Oscar Argueta
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 28.0
WATER LEVEL DURING DRILLING (ft-bgs): 5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
					3		
10	Fill		SAND and GRAVEL fill.	SS-03 (1.1)	4 4 5 4	0	
	Fill		No Recovery, inferred to be SAND and GRAVEL fill.	na	na na na na	0	Top of PEAT 14 ft-bgs
15				SS-04 (2.0)	1 1 1 1		
				SS-05 (0.5)	1 1 1 1		
					1		

NOTES:

Top 6 ft cleared with air knife/hand auger. Bentonite drilling mud used to keep borehole from collapsing.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-04

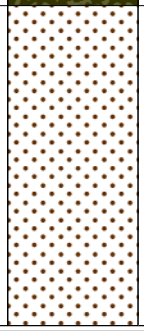
DATE DRILLED: 4/26/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 10.43
NORTHING (ft): 630507.83
EASTING (ft): 563576.17
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough and Oscar Argueta
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 28.0
WATER LEVEL DURING DRILLING (ft-bgs): 5

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
20	Pt		Black to greenish gray Silty PEAT, little organics, trace f sand, moist. Gray fm sand from 23-23.25 ft-bgs.	SS-06 (2.0)	1	<10	Top of SAND 25.5 ft-bgs
					1		
					1		
				SS-07 (1.8)	1		
					1		
					1		
					1		
				SS-08 (1.0)	2		
					2		
					1		
					1		
25				SS-09 (2.0)	5		
					4		
					7		
	SP		Gray FM SAND, with little c sand, some gravel at 27 ft-bgs, wet.		5	0	End of Boring - 28 ft-bgs
				SS-10 (2.0)	8		
					10		
					12		
					12		

NOTES:

Top 6 ft cleared with air knife/hand auger. Bentonite drilling mud used to keep borehole from collapsing.

BOREHOLE LOG: KB19-05

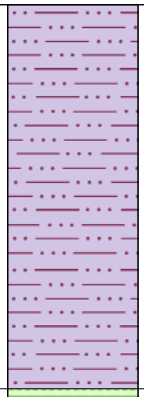
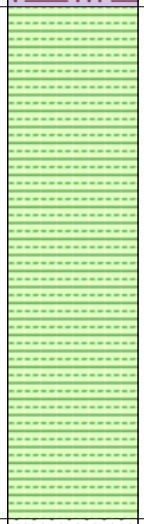
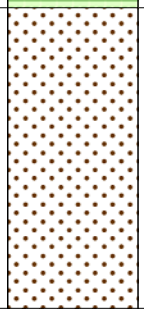
DATE DRILLED: 4/23/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.18
NORTHING (ft): 630384.89
EASTING (ft): 563703.27
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 28.0
WATER LEVEL DURING DRILLING (ft-bgs): 7

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
0	Fill		Orange to brown SILTY FM SAND, with little c sand and some gravel, moist.	Hand Auger NA	Hand Auger NA	0	Fill 0-11.75 ft-bgs
5	Fill		Black SILTY CLAY fill, moist.			<10	
			Gray FM SAND fill, little to some c	SS-01 (2.0)	3 3 2		

NOTES:

Top 8 ft cleared with air knife/hand auger.

BOREHOLE LOG: KB19-05

DATE DRILLED: 4/23/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.18
NORTHING (ft): 630384.89
EASTING (ft): 563703.27
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 28.0
WATER LEVEL DURING DRILLING (ft-bgs): 7

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
10	Fill		sand and gravel, trace silt and clay, wet at 7 ft-bgs.		5	0	
				SS-02 (1.4)	5		
					4		
					2		
					2		Top of PEAT 11.75 ft-bgs
				SS-03 (1.2)	1		
					3		
					2		
					1		
15				SS-04 (1.0)	3		
					2		
					1		
					1		
				SS-05 (2.0)	1		
					WH		
					WH		
					WH		
					2		

NOTES:

Top 8 ft cleared with air knife/hand auger.

KEY ENVIRONMENTAL INCORPORATED

BOREHOLE LOG: KB19-05

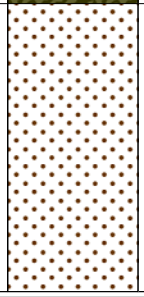
DATE DRILLED: 4/23/19

PROJECT INFORMATION

PROJECT: Buckeye/Hess Terminal North Landfarm
SITE LOCATION: Port Reading, NJ
PROJECT NO: 19819-01-02
KEY FIELD GEOLOGIST: Philip Griffith
GROUND SURFACE ELEVATION (ft): 9.18
NORTHING (ft): 630384.89
EASTING (ft): 563703.27
DATUM: NJSPCS NAD83, NAVD88

DRILLING INFORMATION

DRILLING CO: Unitech Drilling
DRILLER: Bob Hough and Eddie Tavarez
DRILLING RIG: CME 55 Track Rig 390115
DRILLING METHOD: HSA (4.25" ID)
SAMPLING METHOD: ASTM D1586 SPT
HAMMER TYPE: Auto Hammer
TOTAL BORING DEPTH (ft-bgs): 28.0
WATER LEVEL DURING DRILLING (ft-bgs): 7

Depth (ft-bgs)	USCS	Lithology Log	Visual Manual Description	Sample ID Recov (ft/2ft)	Blow Count (N-Value)	PID Detection (ppm)	Comments
20	Pt		Black to greenish gray Silty PEAT, little organics, trace f sand, moist.	SS-06 (0.65)	1 1 1	<10	
				SS-07 (1.5)	1 1 1 1		
				SS-08 (1.9)	1 1 1 1		
25				SS-09 (1.1)	1 1 1 3		Top of SAND 25.75 ft-bgs
	SP		Gray to brownish gray FM SAND, with some c sand, little silt and gravel, wet.	SS-10 (2.0)	6 6 7 8	0	End of Boring - 28 ft-bgs

NOTES:

Top 8 ft cleared with air knife/hand auger.

APPENDIX B

DESIGN CALCULATIONS

Computed by: MRL	Date:	KEY ENVIRONMENTAL INCORPORATED	Client: Earth Systems
Checked by: RCM	Date:		Project: North Landfarm
Page:			Project No.: 19819-02
SUBJECT: Cap System Consolidation Settlement Estimate, AOC-1: North Landfarm, Former Port Reading Refining Facility. Port Reading, NJ			

Objective:

Estimate the potential consolidation settlement of the constructed slope for the North Landfarm cap to ensure a minimum post-construction slope of 3% (typical requirement).

Approach:

Based on an understanding of Site conditions, estimate the maximum differential settlement of the closure cap system. The maximum potential settlement will be estimated using the profiles with the largest (*i.e.*, thickest) compressible layer(s) as determined by the boring logs and cap profile information.

Site Surface Conditions:

Figure A1 presents the existing conditions plan view for the North Landfarm and the proposed cap configuration. The northeast and northwest portions of North Landfarm are defined by the secondary containment system dikes of AST 7945 and smaller dikes on the southeast and southwest sides. North Landfarm encompasses an area of approximately 110 feet (ft) by 160 ft with existing grades ranging from 9 ft to 16 ft. The perimeter grades range from approximately 9 ft to 10 ft. An approximately 6 ft high soil dike surrounds and defines the northeast and northwest limits for the proposed cap.

Site Subsurface Conditions Review:

Figure A2 presents the lithology at each of the boring locations. The boring logs indicate that one highly compressible zone exists within the upper 30 ft of the subsurface: the Peat layer. Table A1 summarizes the peat layer thickness and groundwater depth data. The maximum thickness of the peat layer occurs at KB19-01 and the minimum thickness at KB19-02. At the time of boring installation, the depth to groundwater varied from 0.5 ft below ground surface (ft-bgs) to 7 ft-bgs. Conservatively, the water table will be assumed to be at the existing ground surface to estimate existing vertical effective stress.

TABLE A1 – BORING SUMMARY

Boring ID	Peat Layer Thickness (feet)	Depth Water (ft-bgs)
KB19-01	17.0	0.5
KB19-02	9.5	4.5
KB19-03	12.5	0.5
KB19-04	11.5	5.0
KB19-05	14.0	7.0

Peat Layer Data Review:

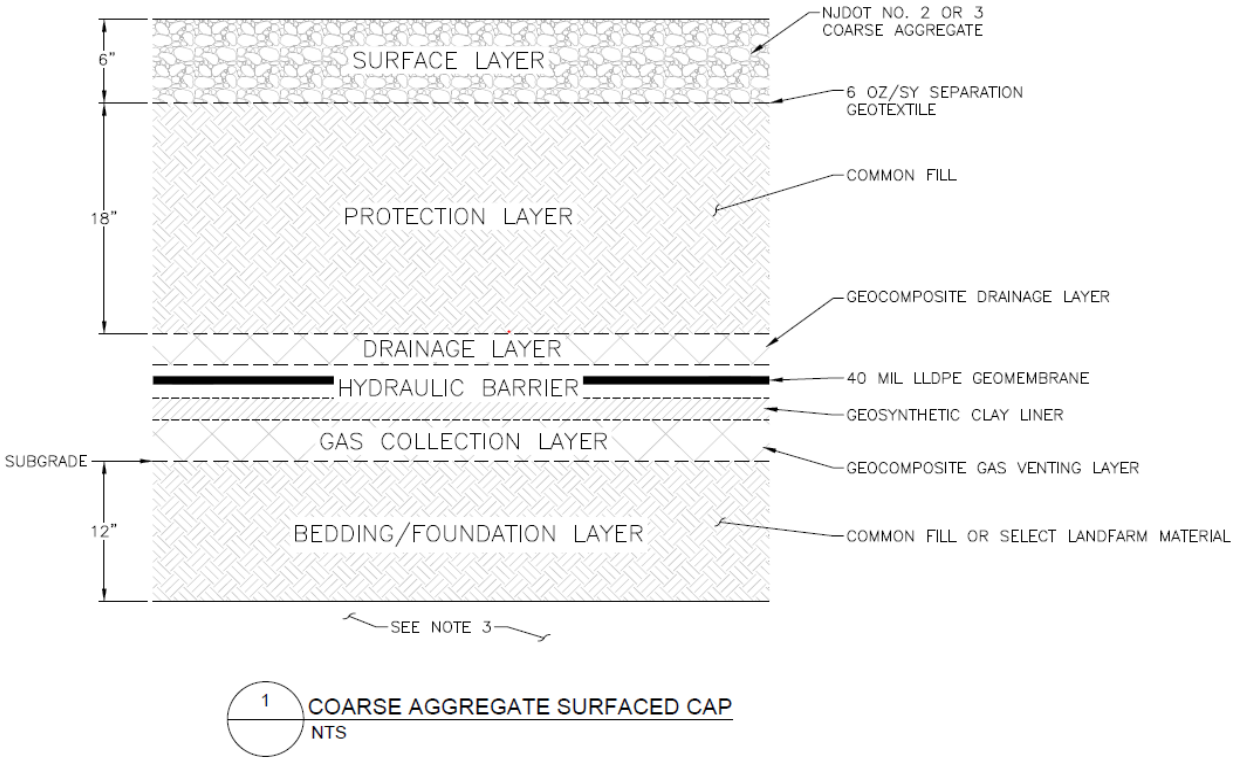
Laboratory testing was conducted using relatively undisturbed peat layer material samples obtained using thin-walled tubes from borings KB19-01 and KB19-02. Four wet unit weights were determined with an average of 92.8 pounds per cubic foot (pcf). Two consolidation tests were conducted (see Figures A4 and A5). The tests indicated a normally consolidated material. The Cc values were calculated using the 0.5 to 2.0 tons per square foot (tsf) loading range to represent the existing vertical effective stress and cap loading. The Cr values were determined from the unloading / reloading portion of the graphs. The sample test results and consolidation parameters determined from those tests are summarized in Table A2 below:

TABLE A2 – PEAT LAYER TEST RESULT SUMMARY

Boring	Wet Unit Weight (pcf)	e_o	C_c	C_r
KB19-01	85.1	3.16	0.639	0.111
KB19-01	94.6			
KB19-02	96.6	1.34	0.339	0.026
KB19-02	94.7			
Average =	**92.8**			

Proposed Cap Configuration:

Figures A1 and A3 depict the draft final grading plan surface and cross-sections. The final elevations range from approximately 11 ft to 14.3 ft. The cap will be constructed of, in ascending order: bedding/foundation layer, geosynthetic materials, protection layer, and surface layer. The material types and thicknesses are shown below:



Assigned Soil Properties:

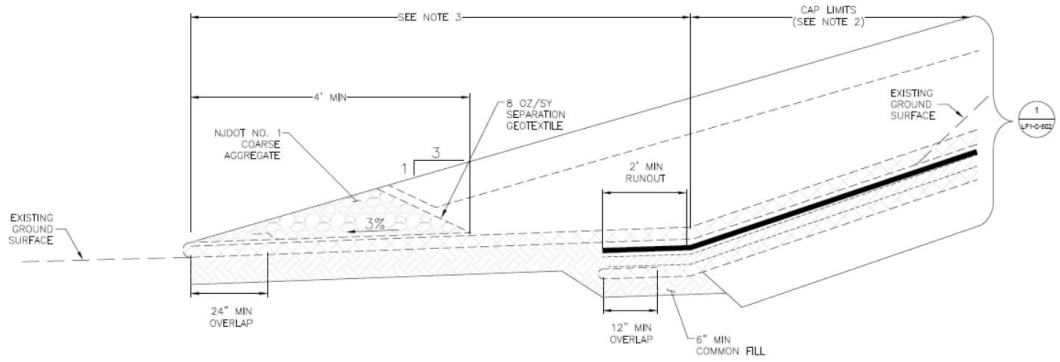
Based on engineering judgement, the following values are assigned for the evaluation: coarse aggregate/gravel (surface layer) 130 pcf unit weight, geosynthetic materials at 5 psf and applied as a surface load, soil (protection layer) 120 pcf, soil fill (bedding/foundation layer) 120 pcf, existing fill 115 pcf, and peat layer 92.8 pcf.

Primary Consolidation Calculation Overview:

Primary consolidation settlement will be estimated for the normally consolidated peat layer. Due to the variability in the consolidation test results, the evaluation will be conducted using conditions at KB19-01 and KB19-02 as representative of the range anticipated under the cap loading. The estimate will be based on the stresses at the midpoint of the peat layer. The increase in vertical effective stress is estimated at each boring location conservatively assuming a uniformly applied surface load based on the increase in load at the respective boring location. Sheet #1 (page 14) and Sheet #2 (page 15) present the results of the primary consolidation calculations. The estimated primary consolidation settlement is 0.38 ft (4.6 inches) and 0.29 ft (3.4 inches) at KB19-01 and KB19-02, respectively.

Potential Rebound Assessment at Edge of Cap:

As indicated above, an existing dike along the southwestern edge of the proposed cap will be removed. The dike removal could result in some rebound of the peat layer, which would reduce the post construction slope of the cap. The figure below depicts the proposed cap edge layout:



Sheet #3 (page 16) presents the results of the rebound calculation. The estimated rebound due to the southwestern dike removal is estimated at 0.5 inches. This is within the typical tolerance of the construction and is judged to be insignificant.

Time Rate of Primary Consolidation Settlement:

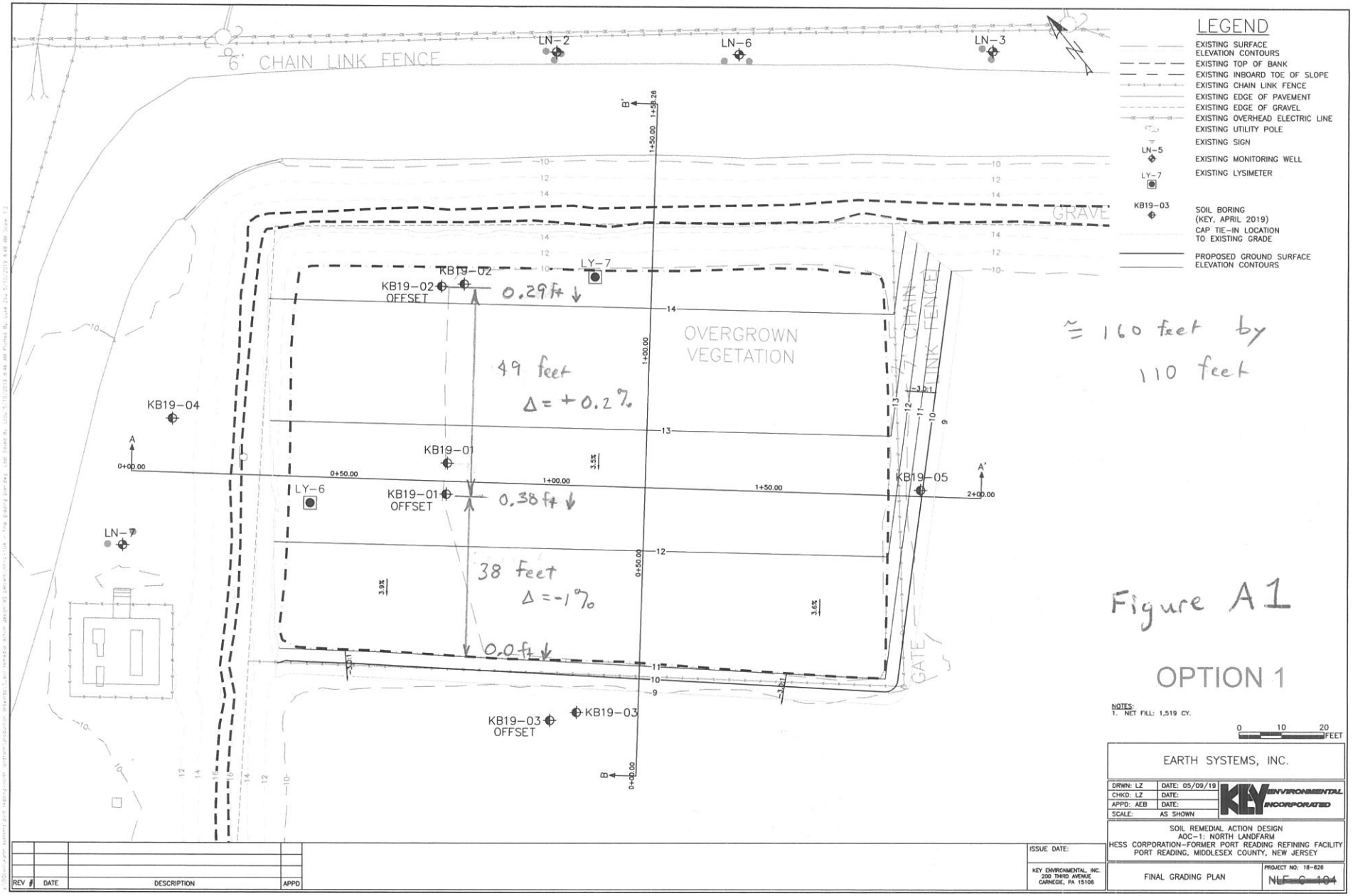
Determine time rate to achieve average of 50% primary consolidation settlement using Taylor's square-root-of-time method (ref. pp. 341 - 345, Perloff, W. H. and Baron, W., 1976. Soil Mechanics - Principles and Applications, Wiley & Sons, New York; pp. 8.28 - 8.29, Day, R. W., 2006, McGraw-Hill, New York). The time rate of primary consolidation will be evaluated for the KB19-01 location (point of maximum estimated settlement). Evaluation of the laboratory test data for the 0.5 to 1.0 tsf (500 to 2,000 psf) load increment with H_o = 0.69 inch (17.6mm) yields C_v = 2.6 x 10^{-3} $inch^2$/min (page 13). Based on a double drained 17 feet thick layer, the time for 50% average consolidation is ~1.5 years (page 17). The estimated time to achieve 50% consolidation is much greater than the anticipated construction duration, therefore, minimal consolidation will occur during construction of the cap.

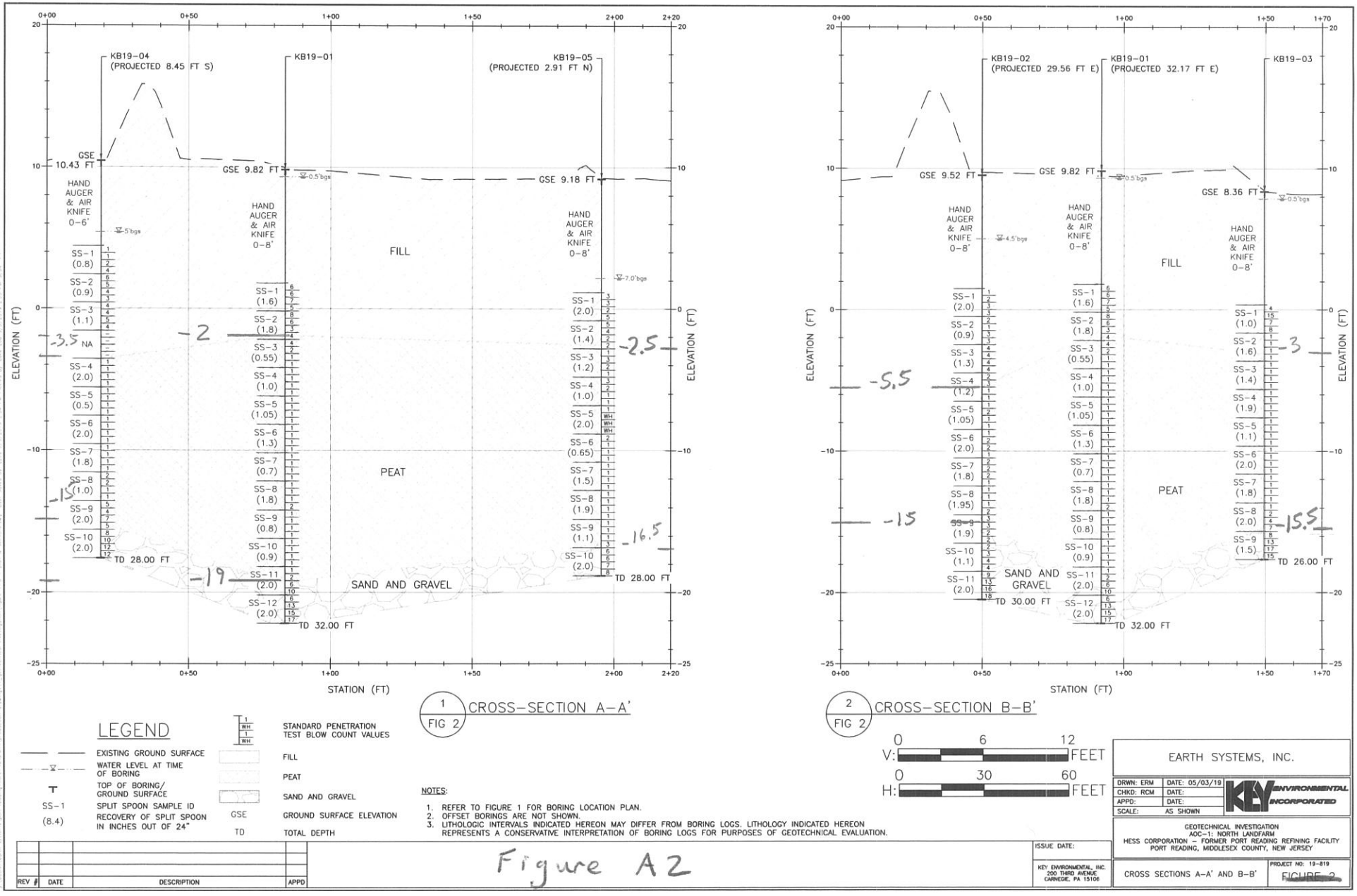
Differential Settlement Estimate:

The differential settlement will be estimated based on the estimated primary consolidation settlement at the boring locations and assuming that the southwest limit of the cap rebounds as estimated above. Figure A1 depicts the settlement, the spacing between the boring locations, and the resulting estimated differential settlement. A slight (+0.2%) increase in the cap slope is estimated from KB19-02 to KB19-01. A 1% decrease in the cap slope is estimated from KB19-01 to the southwest limit of the cap.

Summary and Conclusions:

The peat layer is a highly compressible layer which will settle following construction of the cap. The estimated time for the primary consolidation to be realized will be in years. Based on the evaluation of potential differential settlement, the design cap slope should be 1 percent greater (*i.e.*, 4%) than the required post settlement minimum (*i.e.*, 3%) to accommodate the estimated settlement. The peak elevation, i.e. northeast limit of the cap, will therefore be increased slightly form the draft grading plan presented herein to yield a slope of 4% at time of construction. In addition, the cap termination "daylight" elevation at the southwest limit of the cap will be located set approximately 0.5 ft above existing grade.


LEGEND
EXISTING SURFACE ELEVATION CONTOURS
EXISTING TOP OF BANK
EXISTING INBOARD TOE OF SLOPE
EXISTING CHAIN LINK FENCE
EXISTING EDGE OF PAVEMENT
EXISTING EDGE OF GRAVEL
EXISTING OVERHEAD ELECTRIC LINE
EXISTING UTILITY POLE
EXISTING SIGN
LN-5
EXISTING MONITORING WELL
LY-7
EXISTING LYSIMETER
KB19-03
SOIL BORING (KEY, APRIL 2019)
CAP TIE-IN LOCATION TO EXISTING GRADE
PROPOSED GROUND SURFACE ELEVATION CONTOURS
6' CHAIN LINK FENCE
LN-2
LN-6
LN-3
LN-7
LY-6
LY-7
KB19-01
KB19-02
KB19-03
KB19-04
KB19-05
KB19-01 OFFSET
KB19-02 OFFSET
KB19-03 OFFSET
0.38 ft
0.29 ft
0.0 ft
49 feet
Δ = +0.2%
38 feet
Δ = -1%
OVERGROWN VEGETATION
CHAIN LINK FENCE
GATE
GRAVE
≅ 160 feet by 110 feet
Figure A1
OPTION 1
NOTES:
1. NET FILL: 1,519 CY.
0 10 20 FEET
EARTH SYSTEMS, INC.
DRWN: LZ DATE: 05/09/19
CHKD: LZ DATE:
APPD: AEB DATE:
SCALE: AS SHOWN
KEY ENVIRONMENTAL INCORPORATED
SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY
FINAL GRADING PLAN
PROJECT NO: 18-826
NLF-C-104
ISSUE DATE:
KEY ENVIRONMENTAL, INC. 200 THIRD AVENUE CARNEGIE, PA 15106
REV # DATE DESCRIPTION APPD



1 FIG 2 CROSS-SECTION A-A'

2 FIG 2 CROSS-SECTION B-B'

LEGEND

- EXISTING GROUND SURFACE
- WATER LEVEL AT TIME OF BORING
- T TOP OF BORING/ GROUND SURFACE
- SS-1 SPLIT SPOON SAMPLE ID
- (8.4) RECOVERY OF SPLIT SPOON IN INCHES OUT OF 24"
- 1 WH 1 WH STANDARD PENETRATION TEST BLOW COUNT VALUES
- FILL
- PEAT
- SAND AND GRAVEL
- GSE GROUND SURFACE ELEVATION
- TD TOTAL DEPTH

NOTES:

1. REFER TO FIGURE 1 FOR BORING LOCATION PLAN.
2. OFFSET BORINGS ARE NOT SHOWN.
3. LITHOLOGIC INTERVALS INDICATED HEREON MAY DIFFER FROM BORING LOGS. LITHOLOGY INDICATED HEREON REPRESENTS A CONSERVATIVE INTERPRETATION OF BORING LOGS FOR PURPOSES OF GEOTECHNICAL EVALUATION.

V: 0 6 12 FEET

H: 0 30 60 FEET

REV #	DATE	DESCRIPTION	APPD

Figure A2

ISSUE DATE:

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

EARTH SYSTEMS, INC.

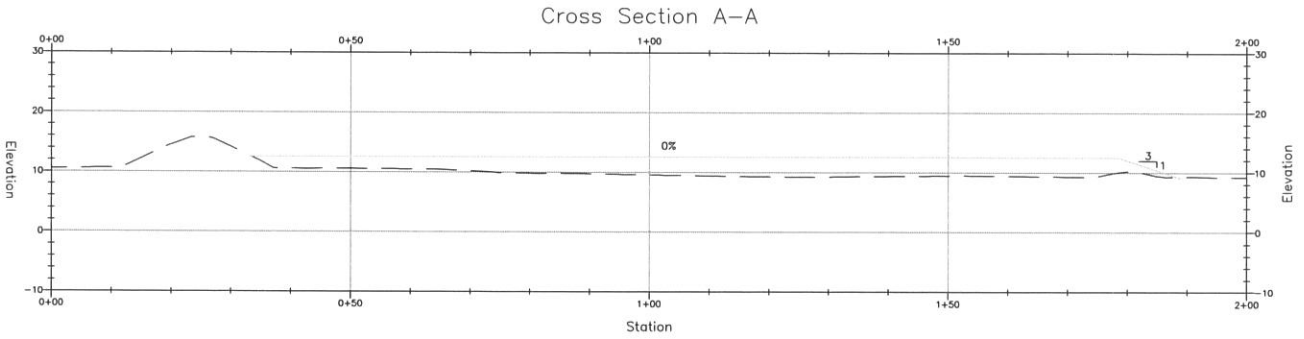
DRWN: ERM	DATE: 05/03/19
CHKD: RCM	DATE:
APPD:	DATE:
SCALE:	AS SHOWN

KEY ENVIRONMENTAL INCORPORATED

GEOTECHNICAL INVESTIGATION
AOC-1: NORTH LANDFARM
HESS CORPORATION - FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

CROSS SECTIONS A-A' AND B-B'

PROJECT NO: 19-819
FIGURE 2



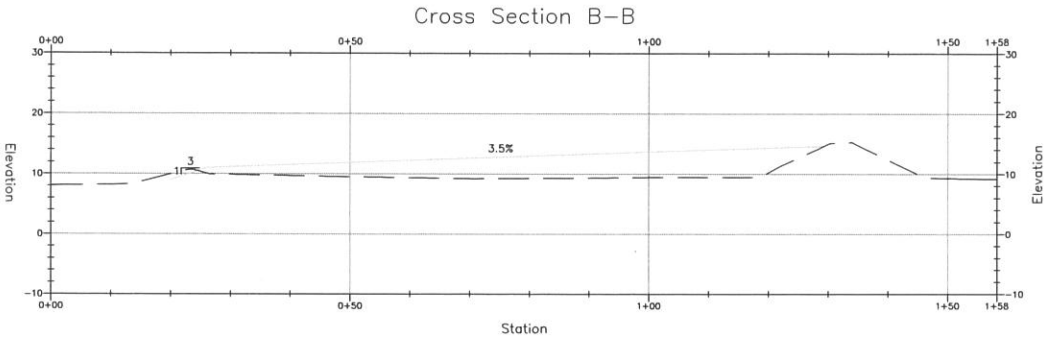


Figure A3

OPTION 1

0 10 20 FEET

EARTH SYSTEMS, INC.

DRWN: LZ	DATE: 05/09/19	KEY ENVIRONMENTAL INCORPORATED
CHKD: LZ	DATE:	
APPD: AEB	DATE:	
SCALE:	AS SHOWN	

SOIL REMEDIAL ACTION DESIGN
AOC–1: NORTH LANDFARM
HESS CORPORATION–FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE:

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

FINAL GRADING PLAN

PROJECT NO: 18-626

NLF-C-104

geotechnics
geotechnical & geosynthetic testing

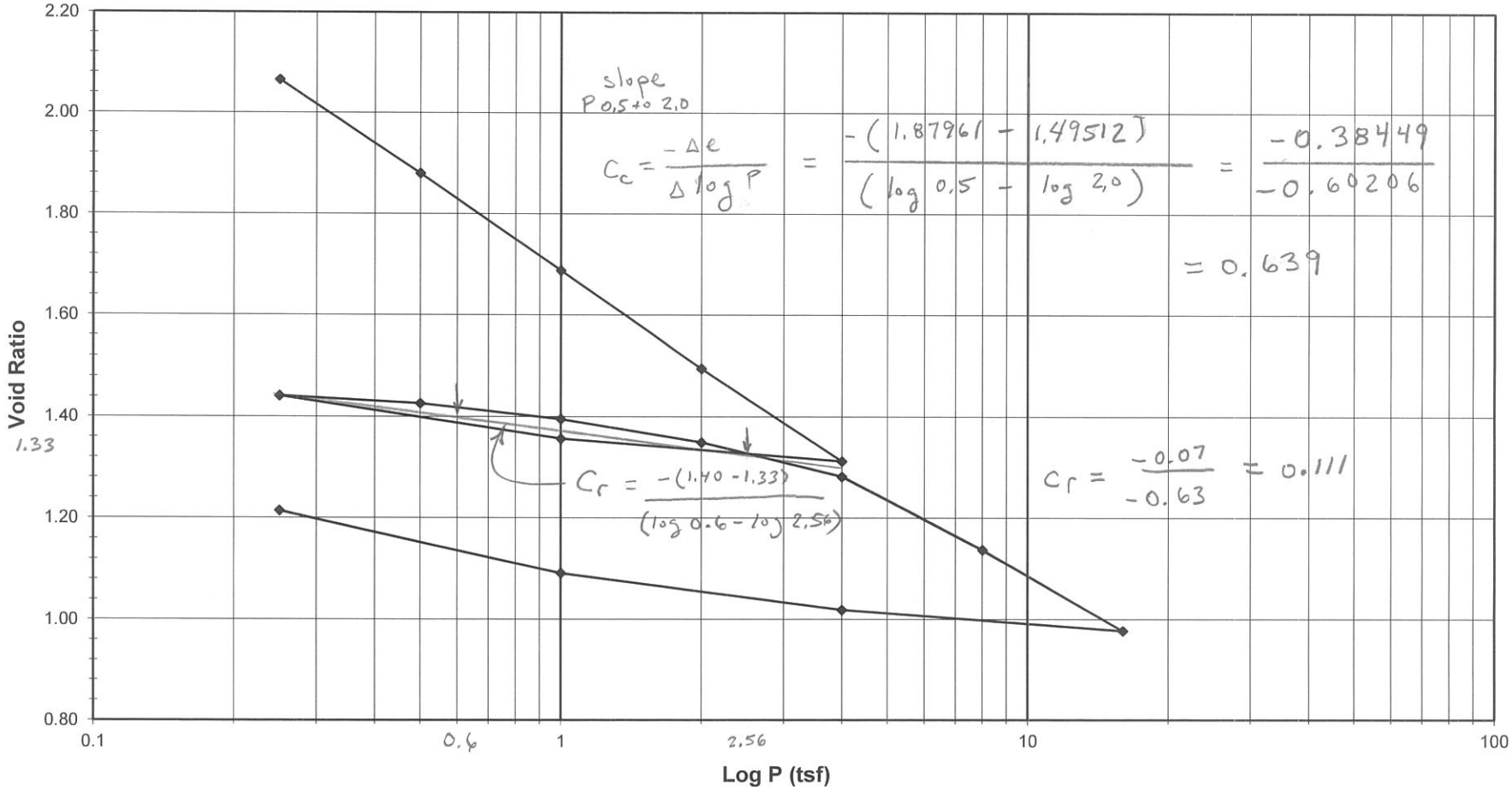
Figure A 4
1/2

ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED



Tested By TM *Date* 5/10/19 *Approved By* NJM *Date* 5/21/19

geotechnics
geotechnical & geosynthetic testing

Figure A4
2/2

ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED
Consolidometer No. G1418
1 Division = 0.0001 (in.)

Sample Properties	Initial	Final
Water Content		
Tare Number	2900	3374
Wt. of Tare & WS (g)	78.85	80.15
Wt. of Tare & DS (g)	39.26	58.87
Wt. of Water (g)	39.59	21.28
Wt. of Tare (g)	8.15	8.33
Wt. of DS (g)	31.11	50.54
Water Content (%)	127.26	42.11
Sample Parameters		
Sample Diameter (in)	2.5	2.5
Sample Height (in)	1.0000	0.5318
Sample Volume (cm^3)	80.44	42.77
Wt. of Wet Sample + Ring (g)	323.73	282.60
Wt. of Ring (g)	213.95	213.95
Wt. of Wet Sample (g)	109.78	68.65
Wet Density (pcf)	85.16	100.14
Wet Density (g/cm^3)	1.36	1.60
Water Content (%)	127.26	42.11
Wt. of Dry Sample (g)	48.31	48.31
Dry Density (pcf)	37.47	70.47
Dry Density (g/cm^3)	0.60	1.13
Void Ratio	3.1630	1.2137
Saturation (%)	100.58	86.73
Specific Gravity	2.50	*Measured*

Test Data Summary

Applied Pressure (tsf)	Final Dial Reading (div)	Machine Deflection (div)	Corrected Reading (div)	Height of Sample (mm)	Volume (cm^3)	Dry Density (g/cm^3)	Void Ratio
Seating	0	0	0	25.400	80.440	0.60053	**3.16301**
0.25	2646.5	9.5	2637.0	18.702	59.228	0.81560	**2.06522**
0.5	3102.3	19.4	3082.9	17.570	55.641	0.86817	**1.87961**
1	3574.4	30.7	3543.7	16.399	51.935	0.93014	**1.68778**
2	4051.0	44.6	4006.4	15.224	48.212	1.00195	**1.49512**
4	4520.3	72.8	4447.5	14.103	44.664	1.08155	**1.31151**
1	4378.8	38.5	4340.3	14.376	45.527	1.06106	**1.35614**
0.25	4156.4	20.2	4136.2	14.894	47.169	1.02412	**1.44112**
0.5	4194.9	23.0	4171.9	14.803	46.881	1.03039	**1.42626**
1	4278.6	31.9	4246.7	14.614	46.280	1.04379	**1.39512**
2	4402.9	45.3	4357.7	14.332	45.387	1.06432	**1.34891**
4	4593.7	73.2	4520.5	13.918	44.077	1.09594	**1.28114**
8	4972.1	106.4	4865.7	13.041	41.300	1.16964	**1.13741**
16	5394.3	143.8	5250.5	12.064	38.205	1.26441	**0.97720**
4	5234.0	83.5	5150.5	12.318	39.010	1.23832	**1.01887**
1	5019.1	42.0	4977.1	12.758	40.404	1.19559	**1.09102**
0.25	4707.0	24.5	4682.5	13.506	42.774	1.12934	**1.21368**

Tested By *TM* *Date* *5/10/19* *Input Checked By* *NJM* *Date* *5/21/19*

DCN: CT-24E Date: 8/15/12 Revision: 2

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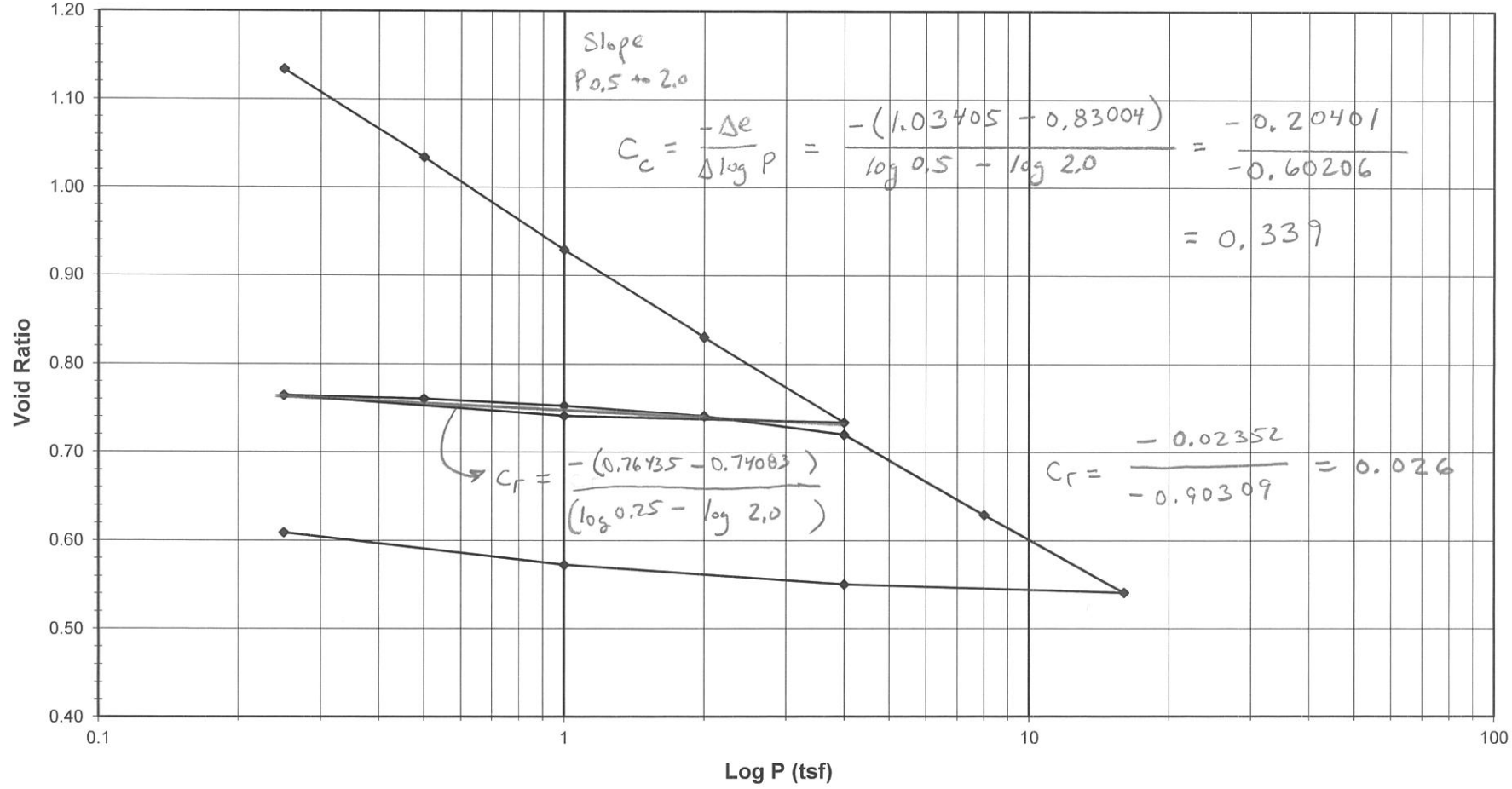
Figure A5
1/2

ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED



Tested By TM *Date* 5/13/19 *Approved By* NJM *Date* 4/23/19

geotechnics
geotechnical & geosynthetic testing

Figure A5
2/2

ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-02
Client Project:	North Landfarm 19819 01 02	Depth (ft):	19.2-19.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-004	Visual Description:	Soft Gray Clay with Sand Layers and Organics

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED
Consolidometer No. G1427
1 Division = 0.0001 (in.)

Sample Properties	Initial	Final
Water Content		
Tare Number	3236	3152
Wt. of Tare & WS (g)	94.15	115.33
Wt. of Tare & DS (g)	63.88	93.45
Wt. of Water (g)	30.27	21.88
Wt. of Tare (g)	8.16	8.14
Wt. of DS (g)	55.72	85.31
Water Content (%)	54.33	25.65
Sample Parameters		
Sample Diameter (in)	2.5	2.5
Sample Height (in)	1.0000	0.6876
Sample Volume (cm^3)	80.44	55.31
Wt. of Wet Sample + Ring (g)	346.03	321.58
Wt. of Ring (g)	214.46	214.46
Wt. of Wet Sample (g)	131.57	107.12
Wet Density (pcf)	102.06	120.86
Wet Density (g/cm^3)	1.64	1.94
Water Content (%)	54.33	25.65
Wt. of Dry Sample (g)	85.26	85.26
Dry Density (pcf)	66.14	96.19
Dry Density (g/cm^3)	1.06	1.54
Void Ratio	1.3399	0.6088
Saturation (%)	100.55	104.47
Specific Gravity	2.48	*Measured*

Test Data Summary

Applied Pressure (tsf)	Final Dial Reading (div)	Machine Deflection (div)	Corrected Reading (div)	Height of Sample (mm)	Volume (cm^3)	Dry Density (g/cm^3)	Void Ratio
Seating	0	0	0	25.400	80.440	1.05986	**1.33993**
0.25	883.6	3.1	880.5	23.164	73.357	1.16219	**1.13390**
0.5	1315.6	8.4	1307.2	22.080	69.925	1.21924	**1.03405**
1	1777.1	22.0	1755.2	20.942	66.321	1.28549	**0.92923**
2	2217.2	38.1	2179.1	19.865	62.911	1.35516	**0.83004**
4	2654.8	64.1	2590.7	18.820	59.600	1.43045	**0.73372**
1	2592.8	33.8	2559.0	18.900	59.855	1.42435	**0.74114**
0.25	2470.4	10.6	2459.8	19.152	60.653	1.40562	**0.76435**
0.5	2488.8	12.7	2476.1	19.111	60.522	1.40866	**0.76053**
1	2534.6	24.6	2510.0	19.025	60.250	1.41503	**0.75262**
2	2598.3	38.0	2560.3	18.897	59.844	1.42461	**0.74083**
4	2713.8	64.0	2649.7	18.670	59.125	1.44194	**0.71991**
8	3136.8	99.6	3037.3	17.685	56.008	1.52219	**0.62923**
16	3571.2	156.7	3414.4	16.727	52.974	1.60937	**0.54097**
4	3457.0	83.9	3373.0	16.832	53.307	1.59932	**0.55066**
1	3315.4	36.6	3278.8	17.072	54.065	1.57690	**0.57271**
0.25	3139.0	14.6	3124.4	17.464	55.307	1.54148	**0.60884**

Tested By TM *Date* 5/13/19 *Input Checked By* NJM *Date* 4/23/19

DCN: CT-24E Date: 8/15/12 Revision: 2

GeoJac-32tsf.xlt

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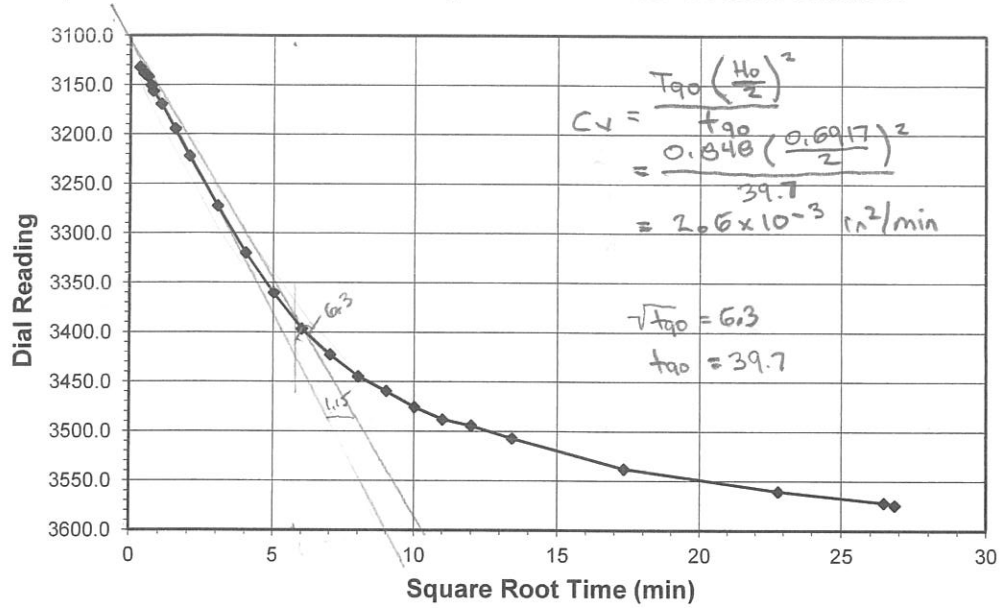
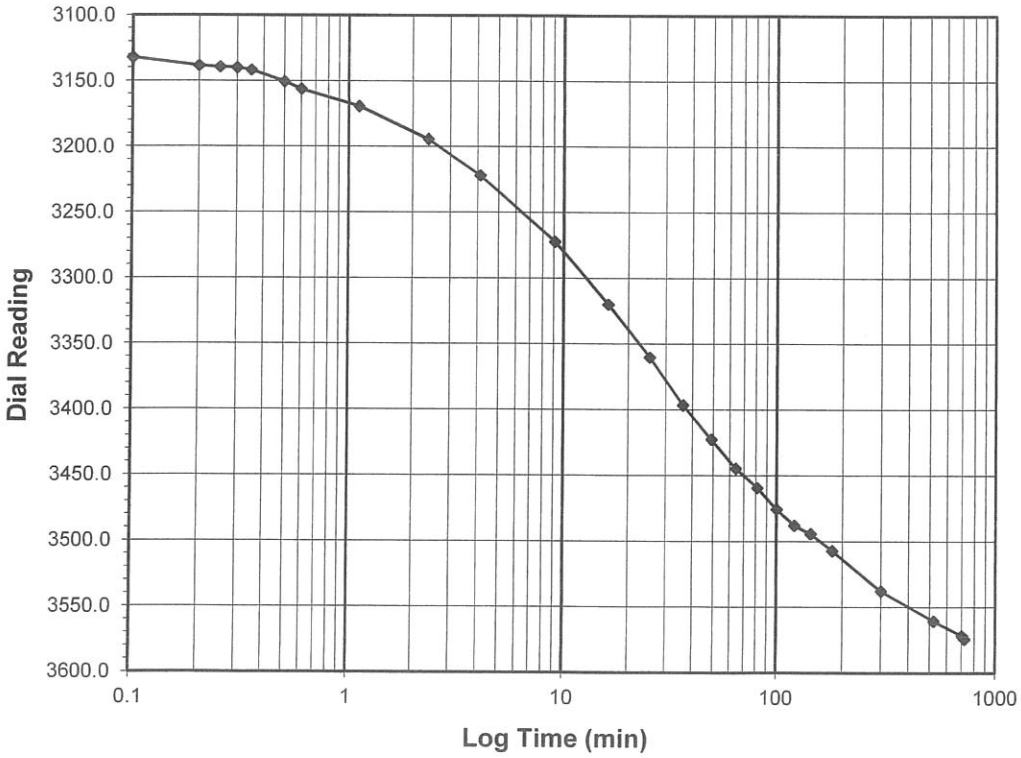
ONE DIMENSIONAL CONSOLIDATION

ASTM D2435 / D2435M-11

Client:	Key Environmental, Inc.	Boring No.:	KB19-01
Client Project:	North Landfarm 19819 01 02	Depth (ft):	15.2-15.7
Project No.:	2019-264-001	Sample No.:	ST-1A
Lab ID:	2019-264-001-001	Visual Description:	Very Soft Gray Clay / Trace Sand

Sample Conditions: UNDISTURBED, INUNDATED AND DOUBLE DRAINED





Test Load	**(tsf)**	**0.5 - 1**
Final Reading	**(div)**	**3574.4**
Consolidometer No.		**G1418**
1 Division	(in)	0.0001
Start Date		5/11/19
Start Time		7:22:27

Elapsed Time (min)	Dial Reading (div)
Initial	**3102.3**
0.10	3132.3
0.20	3138.6
0.25	3139.5
0.30	3140.0
0.35	3141.9
0.50	3150.7
0.60	3156.3
1.12	3169.4
2.37	3194.4
4.12	3222.0
9.12	3272.4
16.12	3320.0
25.12	3360.2
36.12	3396.6
49.12	3422.7
64.12	3444.7
81.12	3459.5
100.12	3475.6
121.12	3488.0
144.12	3494.4
180.12	3507.2
300.12	3537.8
520.12	3560.6
700.12	3571.8
720.25	3574.4

$H_o = 17.570$ mm
$H_o = 0.6917$ inch

Tested By TM *Date* 5/11/19 *Checked By* NJM *Date* 5/21/19

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PRIMARY CONSOLIDATION SETTLEMENT CALCULATION SHEET **Sheet #1**

PROJECT: Hess Corporation
LOCATION: North Landfarm
LOAD CASE: Final Cap Loading

Done By: MRL Date: 8/8/2019
Checked By: RCM Date:
Data Entry Checked by: Date:

Elevation	Layer	Total Unit Weight (PCF)	Layer Thickness (feet)	Layer Total Overburden Stress (PSF)	Layer Pore Pressure (PSF)	Initial Layer Effective Stress (PSF)	Initial Cumulative Effective Stress (PSF)	Final Cumulative Load Stress (PSF)	Note
	Surface Load			5				5	geosynthetics, etc.
12.6	Gravel	130	0.5	65				70.0	Cap Surface
12.1	Protection Layer	120	1.5	180				250.0	
10.6	Soil Fill	120	0.8	96	0		0.0	346.0	
9.8	Existing Fill	115	11.8	1357	736.32	620.7	620.7		Ex Grade/Water
-2.0	Peat	92.8	8.5	788.8	530.4	258.4	879.1		Midpoint
-10.5	Peat	92.8	8.5	788.8	530.4	258.4	1137.5		
-19.0	Sand / Gravel			0	0	0.0	1137.5		

Peat Layer				
Layer Thickness, H =		17.0	feet	
Initial Void Ratio, e_o =		3.16		Sample KB19-01, 15.2 to 15.7 ft bgs results
Initial Midpoint Effective Stress		879.1	psf	
Stress Increase from Loading		346.0	psf	
	Stress Ratio	0.39		
	C_c =	0.639	normally consolidated	Sample KB19-01, 15.2 to 15.7 ft bgs Results
	Consolidation =	0.38	feet	

Estimated Settlement = 0.38 feet
4.5 inches

Primary Consolidation Settlement Equation for one layer

Consolidation =
$(C_c / 1 + e_o) \times H \times \{ \log (\text{Initial Effective Stress} + \text{Loading Stress}) / \text{Initial Effective Stress} \}$
for normally consolidated clay (ref. p. 223, Soil Mechanics Principles and Applications, Bowles)

( ) - denotes negative value.

PRIMARY CONSOLIDATION SETTLEMENT CALCULATION SHEET **Sheet #2**

PROJECT: Hess Corporation
LOCATION: North Landfarm
LOAD CASE: Final Cap Loading

Done By: MRL Date: 8/8/2019
Checked By: RCM Date:
Data Entry Checked by: Date:

Elevation	Layer	Total Unit Weight (PCF)	Layer Thickness (feet)	Layer Total Overburden Stress (PSF)	Layer Pore Pressure (PSF)	Initial Layer Effective Stress (PSF)	Initial Cumulative Effective Stress (PSF)	Final Cumulative Load Stress (PSF)	Note
	Surface Load			5				5	geosynthetics, etc.
14.1	Gravel	130	0.5	65				70.0	Cap Peak
13.6	Protection Layer	120	1.5	180				250.0	
12.1	Soil Fill	120	2.7	324	0		0.0	574.0	
9.4	Existing Fill	115	15.0	1725	936	789.0	789.0		Ex Grade/Water
-5.6	Peat	92.8	4.8	445.44	299.52	145.9	934.9		Midpoint
-10.4	Peat	92.8	4.7	436.16	293.28	142.9	1077.8		
-15.1	Sand / Gravel								

Peat Layer				
Layer Thickness, H =		9.5	feet	
Initial Void Ratio, e_o =		1.34		Sample KB19-02, 19.2 to 19.7 ft bgs Results
Initial Midpoint Effective Stress		934.9	psf	
Stress Increase from Loading		574.0	psf	
	Stress Ratio	0.61		
	C_c =	0.339	normally consolidated	Sample KB19-02, 19.2 to 19.7 ft bgs Results
	Consolidation =	0.29	feet	

Estimated Settlement = 0.29 feet
3.4 inches

Primary Consolidation Settlement Equation for one layer

Consolidation =
$(C_c / 1 + e_o) \times H \times \{ \log (\text{Initial Effective Stress} + \text{Loading Stress}) / \text{Initial Effective Stress} \}$
for normally consolidated clay (ref. p. 223, Soil Mechanics Principles and Applications, Bowles)

( ) - denotes negative value.

PRIMARY CONSOLIDATION SETTLEMENT CALCULATION SHEET **Sheet #3**

PROJECT: Hess Corporation
LOCATION: North Landfarm
LOAD CASE: Final Cap Loading

Done By: MRL Date: 8/8/2019
Checked By: RCM Date:
Data Entry Checked by: Date:

Elevation	Layer	Total Unit Weight (PCF)	Layer Thickness (feet)	Layer Total Overburden Stress (PSF)	Layer Pore Pressure (PSF)	Initial Layer Effective Stress (PSF)	Initial Cumulative Effective Stress (PSF)	Final Cumulative Load Stress (PSF)	Note
	Surface Load	120	(2.0)	(240)				(240)	Proposed Cut (existing Dike 1.5 to 2.4 ft high
				0	0		0.0	(240)	
11.0	Existing Fill	115	14.0	1610	873.6	736.4	736.4		Ex Grade/Water @ northwest limit
-3.0	Peat	92.8	6.25	580	390	190.0	926.4		@ KB19-03 location. Midpoint of peat layer
-9.3	Peat	92.8	6.25	580	390	190.0	1116.4		
-15.5	Sand / Gravel								

Peat Layer				
Layer Thickness, H =		12.5	feet	@ KB19-03 location
Initial Void Ratio, e_o =		3.16		Sample KB19-01, 15.2 to 15.7 ft bgs Results
Initial Midpoint Effective Stress		926.4	psf	
Stress Increase from Loading		(240)	psf	
	Stress Ratio	(0.26)		
	C_r =	0.111	normally consolidated	Sample KB19-01, 15.2 to 15.7 ft bgs Results
	Consolidation =	(0.04)	feet	

Estimated Settlement (Rebound) = (0.043) feet
(0.5) inches

Primary Consolidation Settlement Equation for one layer

Rebound =
(C_r / 1 + e_o) x H x { log (Initial Effective Stress + Loading Stress) / Initial Effective Stress) }
for normally consolidated clay (ref. p. 223, Soil Mechanics Principles and Applications, Bowles)

( ) - denotes negative value.

Computed by: MRL 8/8/19 **Sheet #4**
Checked by: RCM 8/8/19

Estimate time to achieve a certain average consolidation for a specific material.

Based on the One Dimensional Consolidation Test result for sample KB19-01.

Cv = 0.0026 inch^2 / minute

This value was determined using Taylor's Square-Root-of-Time Method (page 13).

Determining C_v using Root Time Method

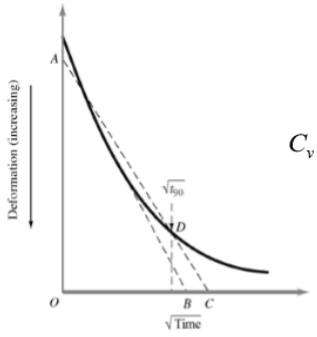


Figure 7.20 Square-root-of-time fitting method

$$T_v = \frac{C_v t}{H^2_{dr}}$$

$$C_v = \frac{T_{V90} H^2_{dr}}{t_{90}} = \frac{0.848\left[\frac{H}{2}\right]^2}{t_{90}}$$

Input Parameters:

Average Consolidation, U% = 50%

T (from chart) = 0.197

for double-drained stratum, Case 1- linear variation (ref. Table 7.7, p. 331, Perloff, W. H. and Baron, W., 1976. Soil Mechanics - Principles and Applications, Wiley & Sons, New York)

Layer Thickness, H = 17 feet

H = 204 inches

Drainage Layers, n = 2 double drainage

Estimated Consolidation Time

t = 788,303 minutes

547 days

1.5 years

$$T = \frac{c_v\, t}{(H/n)^2}$$

Computed: CAZ		Date: 8/22/19	KEY ENVIRONMENTAL INCORPORATED	Client: Earth Systems
Checked: RCM		Date: 8/26/19		Project: North Landfarm
Page 1	of 7			Project No.: 19819 02
SUBJECT: Veneer Slope Stability, Cap System, North Landfarm, Hess Corporation - Former Port Reading Refining Facility				
Middlesex County, Port Reading, NJ				

Objective: Determine the maximum allowable cap plateau slope to maintain a stable geosynthetic cap/cover soil system for the North Landfarm area cap at the Former Port Reading Refining Facility, Port Reading, New Jersey.

References:

1 Figure 1 - Coarse Aggregate Surfaced Cap system.

2 Geosynthetic Fundamentals in Landfill Design, G. N. Richardson, Aigen Zhao, September 8-10, 2009, Proceedings of International Symposium on Geoenvironmental Engineering, Hangzhou, China.

3 Naval Facilities Engineering Command, Design Manual 7.2, Foundations & Earth Structures, Table 1, Typical Properties of Compacted Soils, page 7.2-39.

4 Geotechnical Investigation Report, Soil Remedial Action Design, AOC-1: North Landfarm, Hess Corporation, Former Port Reading Refining Facility, Port Reading, Middlesex County, New Jersey, Key Environmental, Inc. July 10, 2019.

5 Koerner, George R. and Narejo, Dhani, 2005. Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces. Geosynthetic Research Institute, GRI Report #30. June 14.

6 Koerner, R. M. 2012, Designing with Geosynthetics, 6th Edition, Xlibris Corp.

7 Thiel, Richard. Peak vs Residual Shear Strength for Landfill Bottom Liner Stability Analyses, Thiel Engineering, Oregon House CA, USA.

Method: The cap design consists of a geocomposite gas venting layer, geosynthetic clay liner, geomembrane, geocomposite drainage layer, covered by soil with geotextile and coarse aggregate surface treatment. The final grades on the top of the cap are designed to be constructed at 4.0% and have a minimum post settlement grade of 3%. The final grades along the side slope of the cap are designed to be constructed at 3H:1V. Using infinite slope stability analysis, the proposed material interface friction values, and the resulting factors of safety were evaluated for the flatter, plateau portion of the cap.

Step 1: Evaluate the interface friction (shear strength) between layers in the cap system (Figure 1) to identify the potential critical slip surface. From the bottom upward, based on published interface friction results, the interface layers are:

Interface 1 **Common Fill and the Geocomposite Gas Venting Layer**

Based on observations during the geotechnical investigation, the common fill or select landfarm material is a silty-sand material with a typical compacted friction angle of 33^0 (reference 3). The Geocomposite Gas Venting Layer material will be faced on the bottom with a nonwoven (NW) needle-punched (NP) geotextile. Based on Appendix Table 1 (reference 5), the interface friction angle for a NW-NP geotextile to granular soil is 27^0 peak and 21^0 residual.

Use $\delta = 21^0$

Interface 2 **Geocomposite Gas Venting Layer and Geosynthetic Clay Liner**

The top face of the Geocomposite Gas Venting Layer will be exposed geonet. The interface friction angle between the geonet and the bottom NW NP geotextile of the Geosynthetic Clay Liner (GCL) is 23^0 peak and 16^0 residual, based on Appendix Table 1 (reference 5).

Use $\delta = 16^0$

Interface 3A **Geosynthetic Clay Liner and Textured LLDPE Geomembrane**

The interface friction angle between an upper NW NP geotextile component of the GCL and textured LLDPE geomembrane is 26^0 peak and 17^0 residual, based on Appendix Table 1 (reference 5).

textured LLDPE vs upper NW NP geotextile $\delta = 17^0$

The interface friction angle between an upper woven geotextile component of the GCL and textured LLDPE geomembrane is not available in the published literature. Proposed use of an upper woven geotextile must be demonstrated via Contractor submission of representative test results or conducting site-specific testing per technical specification requirements. The residual friction angle is judged to be greater than the critical interface determined via this calculation.

textured LLDPE vs upper woven geotextile $\delta \geq 5.6°$

Interface 3B **Geosynthetic Clay Liner and Smooth LLDPE Geomembrane**

The interface friction angle between an upper NW NP geotextile component of the GCL and smooth LLDPE geomembrane is 10^0 peak and 9^0 residual, based on Appendix Table 1 (reference 5).

smooth LLDPE vs upper NW NP geotextile $\delta = 9^0$

The interface friction angle between an upper woven geotextile component of the GCL and smooth LLDPE geomembrane is not available in the published literature. Proposed use of an upper woven geotextile must be demonstrated via Contractor submission of representative test results or conducting site-specific testing per technical specification requirements. The residual friction angle is judged to be greater than the critical interface determined via this calculation.

smooth LLDPE vs upper woven geotextile $\delta \geq 5.6°$

Interface 4A **Textured LLDPE Geomembrane and Geocomposite Drainage Layer**

Based on Appendix Table 1 (reference 5) for a textured LLDPE and bottom NW NP (i.e. double sided geocomposite drainage layer), the interface friction angle is 26^0 peak and 17^0 residual and for textured LLDPE and the bottom geonet (i.e. single-sided geocomposite drainage layer), the interface friction angle is 15^0 peak and 11^0 residual.

Textured LLDPE $\delta = 11^0$

Interface 4B **Smooth LLDPE Geomembrane and Geocomposite Drainage Layer**

Based on Appendix Table 1 (reference 5) for a smooth LLDPE and bottom NW NP (i.e. double sided geocomposite drainage layer), the interface friction angle is 10^0 peak and 9^0 residual and for smooth LLDPE and the bottom geonet (i.e. single-sided geocomposite drainage layer), the interface friction angle is 11^0 peak and 10^0 residual.

Smooth LLDPE $\delta = 9^0$

Interface 5 and 6 **Geocomposite Drainage Layer and Common Fill**

The common fill is expected to be a silty-sand material with an estimated compacted friction angle of 33^0 (reference 3). The geocomposite drainage layer will be faced on the top with a NW NP geotextile. Based on Appendix Table 1 (reference 5), the interface friction angle for the NW NP geotextile portion of a geocomposite to granular soil is 27^0 peak and 21^0 residual.

Use $\delta = 21^0$

Result: **Interface 3A &3B control, use $\delta \geq 5.6^0$ (use $\delta = 5.6^0$)**

Step 2: For the proposed capping system slope, determine the maximum slope based on the critical interface friction angle for a Factor of Safety = 1.5.

Existing design slope = 4% or 2.29^0.

FS_{slope} = Resisting Forces / Driving Forces

$FS_{slope} = \tan\delta\,[1 - (\gamma_w h_w) / (\gamma_t d)] / \tan\beta$ (ref. 3, assuming no resisting force gained from soil cohesion and no seismic conditions)

β = slope angle of the landfill cap system
δ = cap system component interface friction angle or soil internal friction angle
d = thickness of cover soil = 2 ft
h_w = height of water above interface surface, max = 1.5 feet. (Note cap final surface is a 6 inch cover aggregate layer.)
γ_w = unit weight of water = 62.4 pcf
γ_t = unit weight of soil (USCS SM-SC) = 120 pcf
FS_{slope} = Minimum factor of safety against sliding for soil/geocomposite or geocomposite/geomembrane interface ≥ 1.5

Solution: **4% (2.29^0) slope**

The geocomposite drainage layer is expected to convey the maximum infiltration, and the overlaying cover soil will remain drained. Therefore, the saturated layer ("h_w") will be less than or equal to the thickness of the geocomposite drainage layer which is estimated to be 0.6 cm or 0.24 inches.

a. $h_w = 0$ First, check the minimum interface friction angle required to provide a $FS_{slope} \geq 1.5$ when "h_w" = 0.

$$FS_{slope} = \frac{\tan\delta}{\tan\beta}$$ (ref. 2)

determine δ so the $FS_{slope} = 1.5$

$\tan\beta * FS_{slope} = \tan\delta$

$\delta = \tan^{-1}(\tan\beta * FS_{slope})$ where $\beta = 2.29°$ for 4% slope

$\delta = 3.4°$ < critical interface, $\delta = 5.6°$ OK.

b. $h_w > 0$ Determine the required δ if the common fill layer becomes saturated, with a Factor of Safety = 1.5.

$\tan\delta = [FS \times (\tan\beta) / (1 - (\gamma_w h_w)/(\gamma_t d))$ (ref. 3)

For h_w = 1.5 feet, d = 2 feet

h_w (ft)	tan δ	δ (degrees)	
0.00	0.060	3.4	
0.025	0.061	3.5	= geocomposite drainage layer thickness
0.50	0.069	4.0	
1.00	0.081	4.7	
1.50	0.099	5.6	= maximum saturated thickness
2.00	0.126	7.2	= if coarse aggregate was also saturated the interface friction angle is < critical friction angle. Acceptable for highly unlikely condition.

Check above equation with simplified equation for fully saturated layer:

FS = resisting forces/driving forces = $(\gamma_b * \tan \delta) / (\gamma_{sat} * \tan \beta)$ (ref. 2)
where $\gamma_b = \gamma_t - \gamma_w$ = 120 pcf - 62.4 pcf = 57.6 pcf
FS = (57.6 pcf * tan 7.2°) / (120 pcf *tan 2.3°) = 1.5

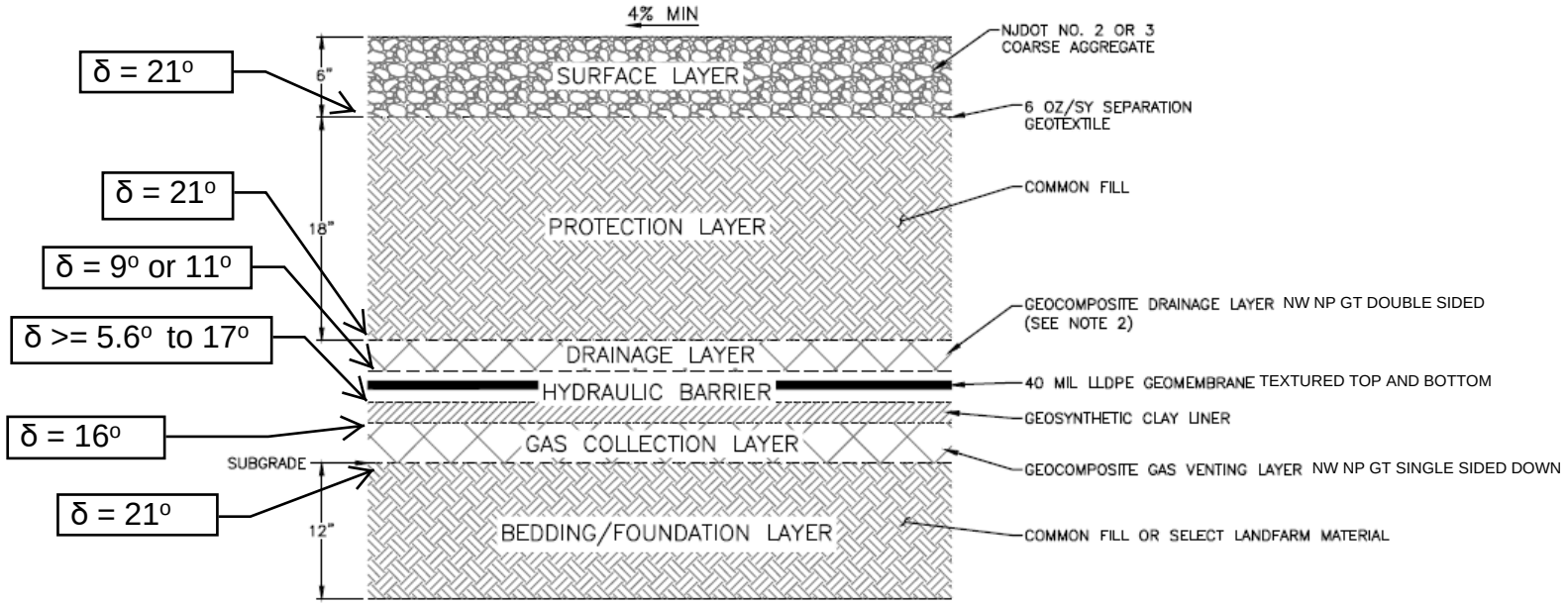
The factor of safety against sliding was estimated to be ≥ 1.5 given: a 2 ft thick cover layer with a slope less than or equal to 4%; saturated to 1.5 feet; infiltration flow parallel to the slope; and, the entire slope length provided the minimum internal shear strength or interface (δ) is at least 5.6°.

Summary: Evaluating a 4% grade with 1) drainage maintained within the geocomposite drainage layer, and 2) a saturated cover material (h_w = 1.5 feet), it was determined that the cap will be stableunder static conditions.

Conclusions: For the proposed North Landfarm capping system, a critical interface friction angle of δ = 5.6° is adequate to maintain a FS ≥ 1.5, with the cap placed at a 4% grade and the 1.5' cover soil fully saturated.

Based on a review of available published technical literature, all peak and residual interface friction angles for the proposed cap system are anticipated to be greater than or equal to the required critical interface friction angle of 5.6^0. Proposed use of an upper woven geotextile for the GCL should be supported by demonstrating that the residual interface angle is at least 5.6^0 via Contractor submission of representative test results or conducting site-specific testing per technical specification requirements.

Actual values are site specific, and may vary with geosynthetic brand and style number, site specific soil, loading, shear rate, and moisture conditions. Therefore, it is suggested that Site specific materials be evaluated for conformance, prior to installation at the Site.



COARSE AGGREGATE SURFACE CAP

TABLE 1
Typical Properties of Compacted Soils

Group Symbol	Soil Type	Range of Maximum Dry Unit Weight, pcf	Range of Optimum Moisture, Percent	Typical Value of Compression		Typical Strength Characteristics				Typical Coefficient of Permeability ft./min.	Range of CBR Values	Range of Subgrade Modulus k lbs/cu in.
				At 1.4 tsf (20 psi)	At 3.6 tsf (50 psi)	Cohesion (as compacted) psf	Cohesion (saturated) psf	ϕ (Effective Stress Envelope Degrees)	Tan ϕ			
				Percent of Original Height								
GW	Well graded clean gravels, gravel-sand mixtures.	125 - 135	11 - 8	0.3	0.6	0	0	>38	>0.79	5×10^{-2}	40 - 80	300 - 500
GP	Poorly graded clean gravels, gravel-sand mix	115 - 125	14 - 11	0.4	0.9	0	0	>37	>0.74	10^{-1}	30 - 60	250 - 400
GM	Silty gravels, poorly graded gravel-sand-silt.	120 - 135	12 - 8	0.5	1.1	.....	.....	>34	>0.67	$>10^{-6}$	20 - 60	100 - 400
GC	Clayey gravels, poorly graded gravel-sand-clay.	115 - 130	14 - 9	0.7	1.6	.....	.....	>31	>0.60	$>10^{-7}$	20 - 40	100 - 300
SW	Well graded clean sands, gravelly sands.	110 - 130	16 - 9	0.6	1.2	0	0	38	0.79	$>10^{-3}$	20 - 40	200 - 300
SP	Poorly graded clean sands, sand-gravel mix.	100 - 120	21 - 12	0.8	1.4	0	0	37	0.74	$>10^{-3}$	10 - 40	200 - 300
SM	Silty sands, poorly graded sand-silt mix.	110 - 125	16 - 11	0.8	1.6	1050	420	34	0.67	$5 \times >10^{-5}$	10 - 40	100 - 300
SM-SC	Sand-silt clay mix with slightly plastic fines.	110 - 130	15 - 11	0.8	1.4	1050	300	33	0.66	$2 \times >10^{-6}$	5 - 30	100 - 300
SC	Clayey sands, poorly graded sand-clay-mix.	105 - 125	19 - 11	1.1	2.2	1550	230	31	0.60	$5 \times >10^{-7}$	5 - 20	100 - 300
ML	Inorganic silts and clayey silts.	95 - 120	24 - 12	0.9	1.7	1400	190	32	0.62	$>10^{-5}$	15 or less	100 - 200
ML-CL	Mixture of inorganic silt and clay.	100 - 120	22 - 12	1.0	2.2	1350	460	32	0.62	$5 \times >10^{-7}$	.....	
CL	Inorganic clays of low to medium plasticity.	95 - 120	24 - 12	1.3	2.5	1800	270	28	0.54	$>10^{-7}$	15 or less	50 - 200
OL	Organic silts and silt-clays, low plasticity.	80 - 100	33 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	50 - 100
MH	Inorganic clayey silts, elastic silts.	70 - 95	40 - 24	2.0	3.8	1500	420	25	0.47	$5 \times >10^{-7}$	10 or less	50 - 100
CH	Inorganic clays of high plasticity	75 - 105	36 - 19	2.6	3.9	2150	230	19	0.35	$>10^{-7}$	15 or less	50 - 150
OH	Organic clays and silty clays	65 - 100	45 - 21	.....	.....	.....	.....	.....	.....	.....	5 or less	25 - 100

Notes:

1. All properties are for condition of "Standard Proctor" maximum density, except values of k and CBR which are for "modified Proctor" maximum density.
2. Typical stength characteristics are for effective strength envelopes and are obtained from USBR data.
3. Compression values are for vertical loading with complete lateral confinement.
4. (>) indicates that typical property is greater than the value shown.
   (..) indicates insufficient data available for an estimate.

Design Manual, Soil Mechanics, Foundation and Earth Structures, NAVFAC DM-7, March 1971

Appendix Table 1. Summary of interface shear strengths.

Interface 1*	Interface 2*	Peak Strength					Residual Strength				
		Fig. No.	δ (deg)	Ca (kPa)	Points	R^2	Fig. No.	δ (deg)	Ca (kPa)	Points	R^2
HDPE-S	Granular Soil	1a	21	0	162	0.93	1b	17	0	128	0.92
HDPE-S	Cohesive Soil										
	Saturated	1c	11	7	79	0.94	1d	11	0	59	0.95
	Unsaturated	1c	22	0	44	0.93	1d	18	0	32	0.93
HDPE-S	NW-NP GT	1e	11	0	149	0.93	1f	9	0	82	0.96
HDPE-S	Geonet	1g	11	0	196	0.90	1h	9	0	118	0.93
HDPE-S	Geocomposite	1i	15	0	36	0.97	1j	12	0	30	0.93
HDPE-T	Granular Soil	2a	34	0	251	0.98	2b	31	0	239	0.96
HDPE-T	Cohesive Soil										
	Saturated	2c	18	10	167	0.93	2d	16	0	150	0.90
	Unsaturated	2c	19	23	62	0.91	2d	22	0	35	0.93
HDPE-T	NW-NP GT	2e	25	8	254	0.96	2f	17	0	217	0.95
HDPE-T	Geonet	2g	13	0	31	0.99	2h	10	0	27	0.99
HDPE-T	Geocomposite	2i	26	0	168	0.95	2j	15	0	164	0.94
LLDPE-S	Granular Soil	3a	27	0	6	1.00	3b	24	0	9	1.00
LLDPE-S	Cohesive Soil	3c	11	12.4	12	0.94	3d	12	3.7	9	0.93
LLDPE-S	NW-NP GT	3e	10	0	23	0.63	3f	9	0	23	0.49
LLDPE-S	Geonet	3g	11	0	9	0.99	3h	10	0	9	1.00
LLDPE-T	Granular Soil	4a	26	7.7	12	0.95	4b	25	5.2	12	0.95
LLDPE-T	Cohesive Soil	4c	21	5.8	12	1.00	4d	13	7.0	9	0.98
LLDPE-T	NW-NP GT	4e	26	8.1	9	1.00	4f	17	9.5	9	0.96
LLDPE-T	Geonet	4g	15	3.6	6	0.97	4h	11	0	6	0.98
PVC-S	Granular Soil	5a	26	0.4	6	0.99	5b	19	0	6	0.99
PVC-S	Cohesive Soil	5c	22	0.9	11	0.88	5d	15	0	9	0.95
PVC-S	NW-NP GT	5e	20	0	89	0.91	5f	16	0	83	0.74
PVC-S	NW-HB GT	5g	18	0	3	1.00	5h	12	0.1	3	1.00
PVC-S	Woven GT	5i	17	0	6	0.54	5j	7	0	6	0.93
PVC-S	Geonet	5k	18	0.1	3	1.00	5l	16	0.6	3	1.00

"Koerner, George R. and Narejo, Dhani, 2005. Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces. Geosynthetic Research Institute, GRI Report #30, June 14."

Appendix Table 1. (continued)

Interface 1*	Interface 2*	Peak Strength					Residual Strength				
		Fig. No.	δ (deg)	Ca (kPa)	Points	R^2	Fig. No.	δ (deg)	Ca (kPa)	Points	R^2
PVC-F	NW-NP GT	6a	27	0.2	26	0.95	6b	23	0	26	0.95
PVC-F	NW-HB GT	6c	30	0	8	0.97	6d	27	0	8	0.90
PVC-F	Woven GT	6e	15	0	6	0.78	6f	10	0	6	0.76
PVC-F	Geonet	6g	25	0	11	1.00	6h	19	0	11	0.99
PVC-F	Geocomposite	6i	27	1.1	5	1.00	6j	22	4.7	6	1.00
CSPE-R	Granular Soil	7a	36	0	3	1.00	7b	16	0	3	1.00
CSPE-R	Cohesive Soil	7c	31	5.7	6	0.71	7d	18	0	6	0.99
CSPE-R	NW-NP GT	7e	14	0	6	0.97	7f	10	0	6	0.98
CSPE-R	NW-HB GT	7g	21	0	3	1.00	7h	10	0	3	1.00
CSPE-R	Woven GT	7i	11	0	6	0.92	7j	11	0	3	1.00
CSPE-R	Geonet	7k	28	0	9	0.87	7l	16	0	9	0.80
NW-NP GT	Granular Soil	8a	33	0	290	0.97	8b	33	0	117	0.96
NW-HB GT	Granular Soil	8c	28	0	6	0.99	8d	16	0	6	0.91
Woven GT	Granular Soil	8e	32	0	81	0.99	8f	29	0	28	0.98
NW-NP GT	Cohesive Soil	9a	30	5	79	0.96	9b	21	0	28	0.79
NW-HB GT	Cohesive Soil	9c	29	0.9	15	0.71	9d	10	0	15	0.83
Woven GT	Cohesive Soil	9e	29	0	34	0.94	9f	19	0	16	0.86
GCL Reinforced (internal)	N/A	10a	16	38	406	0.85	10b	6	12	182	0.91
GCL (NW-NP GT)	HDPE-T	11a	23	8	180	0.95	11b	13	0	157	0.90
GCL (W-SF GT)	HDPE-T	11c	18	11	196	0.96	11d	12	0	153	0.92
Geonet	NW-NP GT	12a	23	0	52	0.97	12b	16	0	32	0.97
Geocomposite (NW-NP GT)	Granular Soil	13a	27	14	14	0.86	13b	21	8	10	0.92

Computed: CAZ	Date: 8/26/19	KEY ENVIRONMENTAL INCORPORATED	Client: Earth Systems
Checked: RCM/MRK	Date: 8/29/19		Project: North Landfarm
Page: 1 of 16			Project No.: 19819 02
SUBJECT: Sideslope Veneer Slope Stability, Cap System, North Landfarm, Hess Corporation - Former Port Reading Refining Facility, Middlesex, County, Port Reading, NJ			

Objective: Evaluate the veneer slope stability of the cap side slope under gravitational and equipment live loads.

References:

1 Geotechnical Investigation Report, Soil Remedial Action Design, AOC-1: North Landfarm, Hess Corporation, Former Port Reading Refining Facility, Port Reading, Middlesex County, New Jersey, Key Environmental, Inc. July 10, 2019.

2 Koerner, R. M. and Soong, T. Y., 2005. "Analysis and Design of Veneer Cover Soils", Geosynthetics International, Volume 12, Issue 1, originally published as the Giroud Lecture in the Proceedings of the Sixth International Geosynthetics Conference held in Atlanta, Georgia in 1998. (relevant pages included herein)

3 Calculation titled Veneer Slope Stability, Cap System, North Landfarm, Hess Corporation - Former Port Reading Refining Facility, Middlesex County, Port Reading, NJ. KEY Environmental, Inc., dated 8/22/19.

4 Koerner, George R. and Narejo, Dhani, 2005. Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces. Geosynthetic Research Institute, GRI Report #30. June 14.

5 Richardson, G. N. and Scheer, P. K., 2006. "The enhancement of interface shear strength between two nonwoven geotextiles", Designer's Forum, Geosynthetics, pp. 10 - 16. April/May.

Method: The stability of the 3H:1V sideslope portion of the cap system will be evaluated for two loading conditions: 1) the weight of the cover soil (gravitational forces) (i.e. static conditions) and, 2) the live load due to construction equipment used to place and compact the cover soil (i.e. "protection layer" and "surface layer"). The potential failure surface for veneer cover soils is typically linear with the cover soil sliding along the soil-to-geosynthetic or geosynthetic-to-geosynthetic interface with the lowest interface friction angle of the cap system. The proposed cap system and cap termination details are presented on the Design Drawings and on page 3 herein.

The full depth cap system covers the flatter plateau portion of North Landfarm. The full depth cap system does not extend down the 3H:1V sideslope (refer to page 3). Soil-to-geosynthetic and geosynthetic-to-geosynthetic interfaces exist within the cap termination and the friction angle of those interfaces will be evaluated. The limit equilibrium analysis based on reference 2 using a simple spreadsheet is then used to estimate the factor of safety. The site specific 3H:1V geometry and it's layers are conservatively simplified to allow estimation of the factor of safety using reference 2 as opposed to having to use two dimensional limit equilibrium software (e.g. STABL, SLOPE/W) to assess the veneer stability. I.e. the site-specific geometry is somewhat complex (refer to page 3) and cannot be readily evaluated using reference 2. The cap termination is therefore conservatively simplified as indicated on page 3 to allow analysis using a simple spreadsheet.

Soil-to-Geosynthetic & Geosynthetic-to-Geosynthetic Interfaces

The upper portion of the 3H:1V sideslope includes interfaces, from bottom to top, as follows: Common Fill to NW NP geotextile portion of Geocomposite Drainage Layer, NW NP geotextile portion of Geocomposite Drainage Layer to Common Fill, and Common Fill to NW NP Separation Geotextile. The critical interface for the aforementioned materials/interfaces was developed in reference 3 (Interface 5 and 6 of ref. 3) and has a residual $\delta = 21°$. Note that the containment elements of the cap system (e.g. gas venting layer, GCL, geomembrane, and drainage layer) extend 2 feet into the sideslope area and are inconsequential to veneer stability of the 3H:1V sideslope.

The lower portion of the 3H:1V sideslope includes interfaces, from bottom to top, as follows:

- Common Fill to NW NP geotextile portion of Geocomposite Drainage Layer (Interface 5 and 6 of ref. 3) with a residual $\delta = 21°$
- NW NP geotextile portion of Geocomposite Drainage Layer to 8 oz/sy NW NP Separation Geotextile ('new' Interface 7) with presumably 'low' peak and residual δ's. The interface friction angle will therefore be enhanced by adding 1 lb/sy of concrete sand to the interface. The peak and residual interface friction angles from Appendix Table 1 of reference 4 for a NW NP geotextile to a granular soil are 33° and 33°, respectively. For an example project (reference 5) with 3H:1V slopes direct shear testing of NW geotextile to NW geotextile (hydrated GCL versus drainage geocomposite) at low normal stresses (200 psf) was conducted and yielded $\delta = 21.1°$. The NW geotextile to NW geotextile interface was enhanced by applying approximately 1 lb/sy of concrete sand and the direct shear testing repeated to yield $\delta = 27.9°$.

The Common Fill to NW NP geotextile portion of Geocomposite Drainage Layer (Interface 5 and 6 of ref. 3) with a residual $\delta = 21°$ is the weakest interface and represents the upper portion of the 3H:1V sideslope. This residual strength is also more critical (i.e. less than) the strength of any soil comprising the sideslope. A $\delta = 21°$ value is conservatively used for the lower portion of the 3H:1V slope and is conservatively modeled as extending parallel to the slope to the toe of the slope for evaluation purposes (refer to page 3). I.e. this modeled critical interface runs through the stronger NJDOT No. 1 Coarse Aggregate.

Gravitational Forces

The equations presented in reference 2 are used in spreadsheet form to estimate the factor of safety.

A factor of safety (FS) of 1.3 was estimated for the 3H:1V sideslopes based on a critical $\delta = 21°$ (page 4) and $c_a = 0$ psf. The FS is less than the generally accepted minimum factor of safety of 1.5.
$\delta = 21°$ equates to a shear strength, $\tau = c_a + N \tan \delta = 0 + (0.5 \text{ ft})(120 \text{ pcf})(\cos 18.4)(\tan 21°) = (56.9 \text{ psf}) \tan 21° = 21.8$ psf.

A factor of safety (FS) of 1.5 was estimated for the 3H:1V sideslopes based on a critical $\delta = 23.5°$ (page 5) and $c_a = 0$ psf. The FS is acceptable.
$\delta = 23.5°$ equates to a shear strength, $\tau = 0 + (0.5 \text{ ft})(120 \text{ pcf})(\cos 18.4)(\tan 23.5) = 24.8$ psf. A minimum shear strength of 24.8 psf at a normal stress of 57 psf for the critical interface is therefore required to provided FS = 1.5. The minimum required shear strength should be specified versus a minimum δ angle owing to the method(s) that may be used to determine the angle from the normal load versus shear strength plots (e.g. secant modulus, best fit, etc.).

A factor of safety (FS) of 1.5 was estimated for the 3.5H:1V sideslopes based on a critical $\delta = 21°$ (page 6) and $c_a = 0$ psf. The FS is acceptable.
The sideslope would need to be reduced to 3.5H:1V and a minimum $\delta = 21°$ equating to a shear strength, $\tau = 22.1$ psf is required. A minimum shear strength of 22 psf at a normal stress of (0.5 ft)(120 pcf)(cos15.94) = 58 psf for the critical interface is therefore required to provided FS = 1.5.

Live Load

Using the analysis for live load as presented on pages 6-12 of reference 2 , the factor of safety can be estimated. Acceleration/deceleration forces are not included in this analysis. Sudden starting, stopping, and sharp turns by heavy equipment operating above geosynthetic materials is not permitted and all heavy equipment operations occurring above geosynthetic materials during construction will be overseen by the CQC and QA inspector(s).

To evaluate a live load due to construction equipment operating bottom up (toe to the crest of slope), it was estimated that the cover soil would be placed using a track-type tractor. Page 16 provides information on typical track type tractors. For this analysis it was estimated that equipment similar to the Caterpillar D5C low ground pressure Series III dozer with 26 inch width tracks would place the soil material. From manufacturer's literature the Caterpillar D5C has a ground pressure of 4.48 psi and a track length of 84.5 inches.

Using the equation presented on page 6 of reference 2, the additional force due to the live load was calculated.

$We = qwI$

$q =$	4.48	psi	
$w =$	84.5	in	
$I =$	0.975	in/in	Influence Factor from Figure 7, page 7 of reference 2, attached.
$We =$	369.1	lb/in	
$We =$	4429.2	lb/ft	

Incorporating the live load into the equations presented on page 5 of reference 2 and using a critical $\delta = 21°$ (page 4) and $c_a = 0$ psf, the FS due to the gravitational force and the live load on the cover soil was determined to be 1.2. The FS is less than the generally accepted minimum factor of safety of 1.3 for short-term or construction conditions.

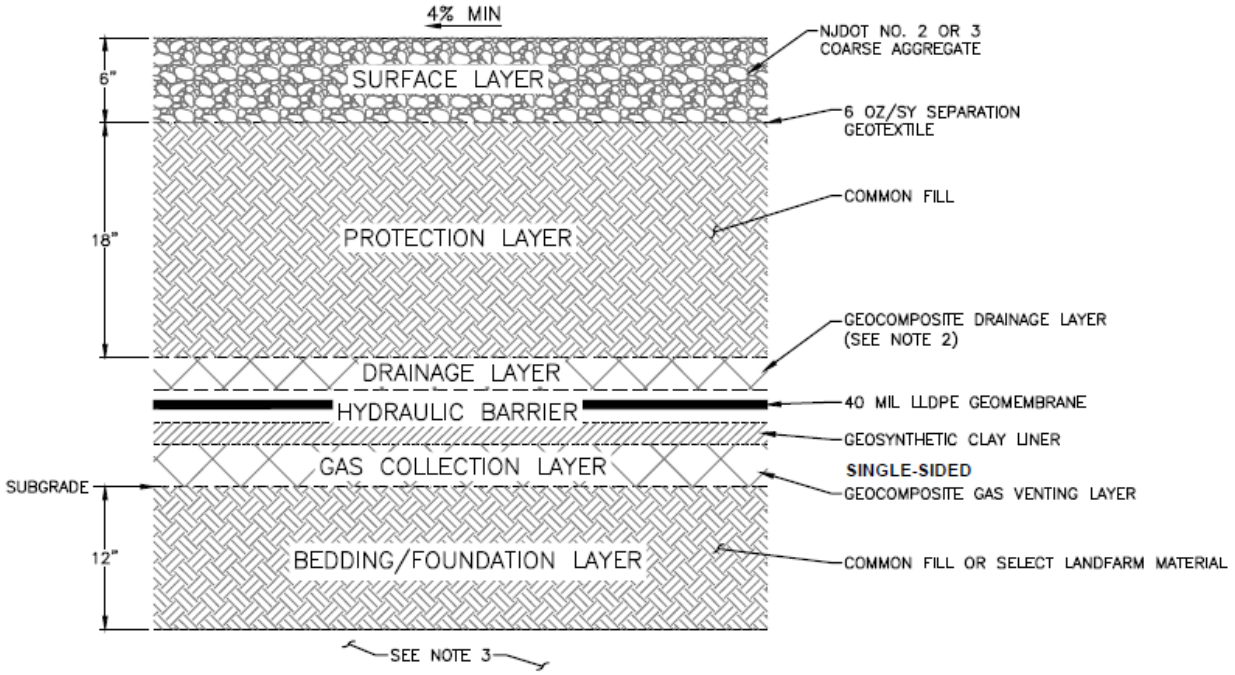
Incorporating the live load into the equations presented on page 5 of reference 2 and using a critical $\delta = 23.5°$ (page 5) and $c_a = 0$ psf, the FS due to the gravitational force and the live load on the cover soil was determined to be 1.3. The FS is acceptable.

Conclusion

The proposed cap system to be installed at the North Landfarm was evaluated for potential sliding under two scenarios. It was found that the factor of safety for the weight of the cover soil (gravitational forces) was greater than the recommended minimum factor of safety. The factor of safety for the temporary live load situation, such as construction equipment similar to the Caterpillar D5C LGP placing and compacting the cover soil and working bottom up is 1.3.

The Factor of Safety for live load with construction equipment working top down was not evaluated and equipment working top down is not permitted.

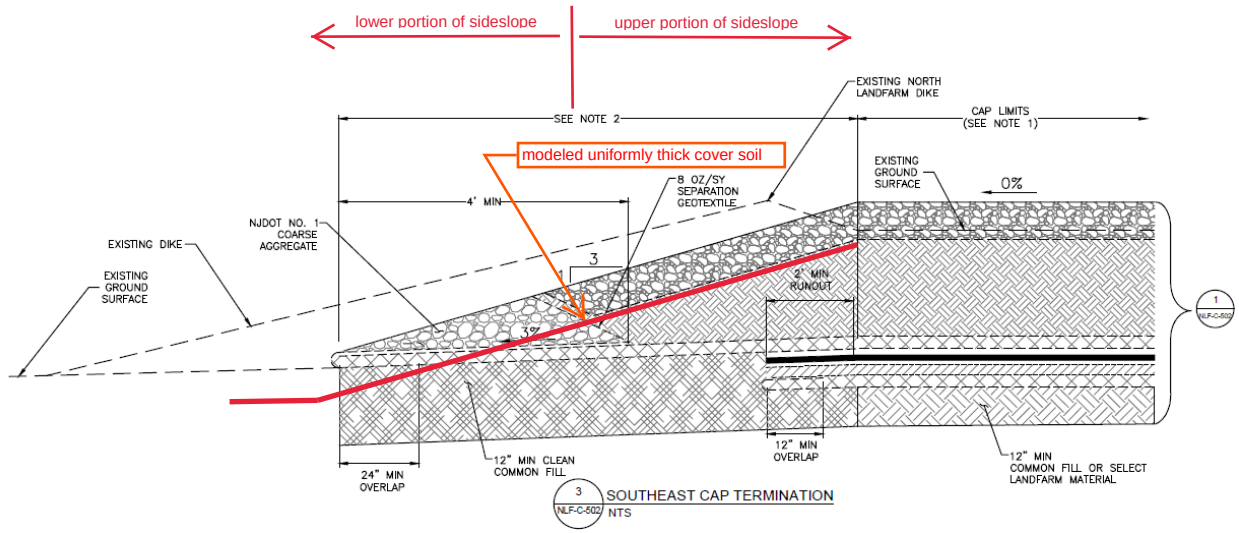
Site-specific direct shear testing should be performed for the critical interface. A minimum residual shear strength of 24.8 psf at a normal stress of approximately 57 psf is required. Alternatively the sideslope may be reduced to 3.5H:1V or a more rigorous two dimensional slope stability analysis performed.



1 NLF-C-502 COARSE AGGREGATE SURFACED CAP NTS

NOTES:

1. PROVIDE SMOOTH OR TEXTURED 40 MIL LLDPE GEOMEMBRANE.
2. PROVIDE DOUBLE–SIDED (SHOWN) OR SINGLE–SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.



3 NLF-C-502 SOUTHEAST CAP TERMINATION NTS

NOTES:

1. PROVIDE DOUBLE–SIDED (SHOWN) OR SINGLE–SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.
2. PROVIDE DOUBLE–SIDED GEOCOMPOSITE DRAINAGE LAYER FROM CAP LIMITS TO CAP TERMINATION.
3. PROVIDE MIN 1 LB/SY CONCRETE SAND BETWEEN DOUBLE-SIDED GEOCOMPOSITE DRAINAGE LAYER AND SEPARATION GEOTEXTILE UNDERLYING NJDOT NO. 1 COARSE AGGREGATE.

Analysis and Design of Veneer Cover Soils
Destabilization of Slopes

Gravitational Forces			Construction Equipment Bottom Up			Notes
γ	120	lb/ft3	γ	120	lb/ft3	NJDOT No. 2 or 3 Coarse Aggregate
h	0.5	ft	h	0.5	ft	thickness of above
L	19	ft	L	19	ft	3H:1V, 6 ft rise
ca	0	lb/ft2	ca	0	lb/ft2	conservatively set to zero
β	18.4	deg	β	18.4	deg	3H:1V slope angle
δ	21	deg	δ	21	deg	for direct shear testing under v. low normal stresses the δ may increase significantly
ϕ	38	deg	ϕ	38	deg	NJDOT No. 2 or 3 Coarse Aggregate; compacted USGS GW
Wa	1040.1	lb/ft	Wa	1040.1	lb/ft	
Na	986.9	lb/ft	Na	986.9	lb/ft	
Ca	0	lb/ft	Ca	0	lb/ft	
Wp	50.1	lb/ft	Wp	50.1	lb/ft	
We		lb/ft	We	4424.11	lb/ft	
Ne		lb/ft	Ne	4197.93	lb/ft	
a	98.33		a	1636.59		
b	(151.38)		b	(2353.00)		
c	29.49		c	490.83		
FS	1.311		FS	1.185		

Solution to the examples presented in the Technical Paper "Analysis and Design of Veneer Cover Soils", R.M Koerner and Te-Yang Soong, Geosynthetic Research Institute.

Equipment Live Loading		
Caterpillar D5C LGP Series III with 26 in wide shoes		
q	4.48	psi
area	4389	in2
b	26	in
w	84.40	in
I	0.975	Koerner
We	368.7	lb/in
We	4424.1	lb/ft

Analysis and Design of Veneer Cover Soils
Destabilization of Slopes

Gravitational Forces			Construction Equipment Bottom Up			Notes
γ	120	lb/ft3	γ	120	lb/ft3	NJDOT No. 2 or 3 Coarse Aggregate
h	0.5	ft	h	0.5	ft	thickness of above
L	19	ft	L	19	ft	3H:1V, 6 ft rise
ca	0	lb/ft2	ca	0	lb/ft2	conservatively set to zero
β	18.4	deg	β	18.4	deg	3H:1V slope angle
δ	23.5	deg	δ	23.5	deg	for direct shear testing under v. low normal stresses the δ may increase significantly
ϕ	38	deg	ϕ	38	deg	NJDOT No. 2 or 3 Coarse Aggregate; compacted USGS GW
Wa	1040.1	lb/ft	Wa	1040.1	lb/ft	
Na	986.9	lb/ft	Na	986.9	lb/ft	
Ca	0	lb/ft	Ca	0	lb/ft	
Wp	50.1	lb/ft	Wp	50.1	lb/ft	
We		lb/ft	We	4424.11	lb/ft	
Ne		lb/ft	Ne	4197.93	lb/ft	
a	98.33		a	1636.59		
b	(166.44)		b	(2603.66)		
c	33.40		c	555.97		
FS	1.460		FS	1.337		

Solution to the examples presented in the Technical Paper "Analysis and Design of Veneer Cover Soils", R.M Koerner and Te-Yang Soong, Geosynthetic Research Institute.

Equipment Live Loading		
Caterpillar D5C LGP Series III with 26 in wide shoes		
q	4.48	psi
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b	26	in
w	84.40	in
i	0.975	Koerner
We	368.7	lb/in
We	4424.1	lb/ft

Analysis and Design of Veneer Cover Soils
Destabilization of Slopes

Gravitational Forces			Construction Equipment Bottom Up			Notes
γ	120	lb/ft3	γ	120	lb/ft3	NJDOT No. 2 or 3 Coarse Aggregate
h	0.5	ft	h	0.5	ft	thickness of above
L	21.8	ft	L	21.8	ft	3.5H:1V, 6 ft rise
ca	0	lb/ft2	ca	0	lb/ft2	conservatively set to zero
β	15.94	deg	β	15.94	deg	3.5H:1V slope angle
δ	21	deg	δ	21	deg	for direct shear testing under v. low normal stresses the δ may increase significantly
ϕ	38	deg	ϕ	38	deg	NJDOT No. 2 or 3 Coarse Aggregate; compacted USGS GW
Wa	1194.6	lb/ft	Wa	1194.6	lb/ft	
Na	1148.6	lb/ft	Na	1148.6	lb/ft	
Ca	0	lb/ft	Ca	0	lb/ft	
Wp	56.8	lb/ft	Wp	56.8	lb/ft	
We		lb/ft	We	4424.11	lb/ft	
Ne		lb/ft	Ne	4254.00	lb/ft	
a	86.63		a	1483.73		
b	(147.95)		b	(2369.60)		
c	25.98		c	444.98		
FS	1.509		FS	1.380		

Solution to the examples presented in the Technical Paper "Analysis and Design of Veneer Cover Soils", R.M Koerner and Te-Yang Soong, Geosynthetic Research Institute.

Equipment Live Loading		
Caterpillar D5C LGP Series III with 26 in wide shoes		
q	4.48	psi
area	4389	in2
b	26	in
w	84.40	in
i	0.975	Koerner
We	368.7	lb/in
We	4424.1	lb/ft

- The issue of appropriate normal stress is greatly complicated if gas pressures are generated in the underlying waste. These gas pressures will counteract some (or all) of the gravitational stress of the cover soil. The resulting shear strength, and subsequent stability, can be significantly decreased. See Liu et al (1997) for insight into this possibility.
- Shear rates necessary to attain drained conditions (if this is the desired situation) are extremely slow, requiring long testing times.
- Deformations necessary to attain residual strengths require large relative movement of the two respective halves of the shear box. So as not to travel over the edges of the opposing shear box sections, devices should have the lower shear box significantly longer than 300 mm. However, with a lower shear box longer than the upper traveling section, new surface is constantly being added to the shearing plane. This influence is not clear in the material's response or in the subsequent behavior.
- The attainment of a true residual strength is difficult to achieve. ASTM D5321 states that one should "run the test until the applied shear force remains constant with increasing displacement". Many commercially available shear boxes have insufficient travel to reach this condition.
- The ring torsion shearing apparatus is an alternative device to determine true residual strength values, but is not without its own problems. Some outstanding issues are the small specimen size, nonuniform shear rates along the width of the specimen, anisotropic shearing with some geosynthetics and no standardized testing protocol. See Stark and Poeppel (1994) for information and data using this alternative test method.

2.3 Various Types of Loadings

There are a large variety of slope stability problems that may be encountered in analyzing and/or designing final covers of engineered landfills, abandoned dumps and remediation sites as well as leachate collection soils covering geomembranes beneath the waste. Perhaps the most common situation is a uniformly thick cover soil on a geomembrane placed over the soil subgrade at a given and constant slope angle. This "standard" problem will be analyzed in the next section. A variation of this problem will include equipment loads used during placement of cover soil on the geomembrane. This problem will be solved with equipment moving up the slope and then moving down the slope.

Unfortunately, cover soil slides have occurred and it is felt that the majority of the slides have been associated with seepage forces. Indeed, drainage above a geomembrane (or other barrier material) in the cover soil cross section must be accommodated to avoid the possibility of seepage forces. A section will be devoted to this class of slope stability problems.

Lastly, the possibility of seismic forces exists in earthquake prone locations. If an earthquake occurs in the vicinity of an engineered landfill, abandoned dump or remediation site, the seismic wave travels through the solid waste mass reaching the upper surface of the cover. It then decouples from the cover soil materials, producing a horizontal force which must be appropriately analyzed. A section will be devoted to the seismic aspects of cover soil slope analysis as well.

All of the above actions are destabilizing forces tending to cause slope instability. Fortunately, there are a number of actions that can be taken to increase the stability of slopes.

Other than geometrically redesigning the slope with a flatter slope angle or shorter slope length, a designer can add soil mass at the toe of the slope thereby enhancing stability. Both toe berms and tapered soil covers are available options and will be analyzed accordingly. Alternatively, the designer can always use geogrids or high strength geotextiles within the cover soil acting as reinforcement materials. This technique is usually referred to as veneer reinforcement. Cases of both intentional and nonintentional veneer reinforcement will be presented.

Thus it is seen that a number of strategies influence slope stability. Each will be described in the sections to follow. First, the basic gravitational problem will be presented followed by those additional loading situations which tend to decrease slope stability. Second, various actions that can be taken by the designer to increase slope stability will be presented. The summary will contrast the FS-values obtained in the similarly crafted numeric examples.

3 SITUATIONS CAUSING DESTABILIZATION OF SLOPES

This section treats the standard veneer slope stability problem and then superimposes upon it a number of situations, all of which tend to destabilize slopes. Included are gravitational, construction equipment, seepage and seismic forces. Each will be illustrated by a design graph and a numeric example.

3.1 Cover Soil (Gravitational) Forces

Figure 3 illustrates the common situation of a *finite* length, uniformly thick cover soil placed over a liner material at a slope angle "β". It includes a passive wedge at the toe and has a tension crack of the crest. The analysis that follows is after Koerner and Hwu (1991), but comparable analyses are available from Giroud and Beech (1989), McKelvey and Deutsch (1991), Ling and Leshchinsky (1997) and others.

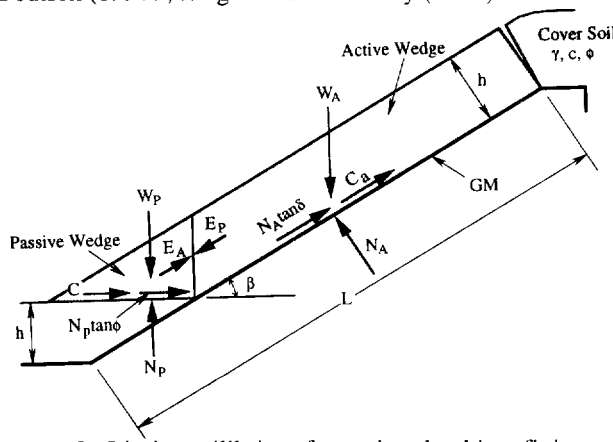


Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil.

The symbols used in Figure 3 are defined below.

W_A = total weight of the active wedge
W_P = total weight of the passive wedge
N_A = effective force normal to the failure plane of the active wedge
N_P = effective force normal to the failure plane of the passive wedge
γ = unit weight of the cover soil
h = thickness of the cover soil
L = length of slope measured along the geomembrane
β = soil slope angle beneath the geomembrane
ϕ = friction angle of the cover soil
δ = interface friction angle between cover soil and geomembrane
C_a = adhesive force between cover soil of the active wedge and the geomembrane
c_a = adhesion between cover soil of the active wedge and the geomembrane
C = cohesive force along the failure plane of the passive wedge
c = cohesion of the cover soil
E_A = interwedge force acting on the active wedge from the passive wedge
E_P = interwedge force acting on the passive wedge from the active wedge
FS = factor of safety against cover soil sliding on the geomembrane

The expression for determining the factor of safety can be derived as follows:

Considering the active wedge,

$$W_A = \gamma h^2\left(\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2}\right) \tag{3}$$

$$N_A = W_A \cos\beta \tag{4}$$

$$C_a = c_a\left(L - \frac{h}{\sin\beta}\right) \tag{5}$$

By balancing the forces in the vertical direction, the following formulation results:

$$E_A \sin\beta = W_A - N_A\cos\beta - \frac{N_A\tan\delta + C_a}{FS}\sin\beta \tag{6}$$

Hence the interwedge force acting on the active wedge is:

$$E_A = \frac{(FS)(W_A - N_A\cos\beta) - (N_A\tan\delta + C_a)\sin\beta}{\sin\beta(FS)} \tag{7}$$

The passive wedge can be considered in a similar manner:

$$W_P = \frac{\gamma h^2}{\sin 2\beta} \tag{8}$$

$$N_p = W_P + E_P\sin\beta \tag{9}$$

$$C = \frac{(c)(h)}{\sin\beta} \tag{10}$$

By balancing the forces in the horizontal direction, the following formulation results:

$$E_P\cos\beta = \frac{C + N_P\tan\phi}{FS} \tag{11}$$

Hence the interwedge force acting on the passive wedge is:

$$E_P = \frac{C + W_P\tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \tag{12}$$

By setting $E_A = E_P$, the resulting equation can be arranged in the form of the quadratic equation $ax^2 + bx + c = 0$ which in our case, using FS-values, is:

$$a(FS)^2 + b(FS) + c = 0 \tag{13}$$

where

$$a = (W_A - N_A\cos\beta)\cos\beta$$

$$b = -\left[(W_A - N_A\cos\beta)\sin\beta\tan\phi + (N_A\tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_P\tan\phi)\right]$$

$$c = (N_A\tan\delta + C_a)\sin^2\beta\tan\phi \tag{14}$$

The resulting FS-value is then obtained from the solution of the quadratic equation:

$$FS = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \tag{15}$$

When the calculated FS-value falls below 1.0, sliding of the cover soil on the geomembrane is to be anticipated. Thus a value of greater than 1.0 must be targeted as being the minimum factor of safety. How much greater than 1.0 the FS-value should be, is a design and/or regulatory issue. The issue of minimum allowable FS-values under different conditions will be assessed at the end of the paper. In order to better illustrate the implications of Eqs. 13, 14 and 15, typical design curves for various FS-values as a function of slope angle and interface friction angle are given in Figure 4. Note that the curves are developed specifically for the variables stated in the legend of the figure. Example 1 illustrates the use of the curves in what will be the standard example to which other examples will be compared.

Example 1:
Given a 30 m long slope with a uniformly thick 300 mm cover soil at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. The cover soil is placed directly on a geomembrane as shown in Figure 3. Direct shear testing has resulted in a interface friction angle between the cover soil and geomembrane of 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg?

Solution:

Substituting Eq. 14 into Eq. 15 and solving for the FS-value results in the following which is seen to be in agreement with the curves of Figure 4.

$$\left.\begin{array}{l} a = 14.7\,kN/m \\ b = -21.3\,kN/m \\ c = 3.5\,kN/m \end{array}\right\} \quad FS = 1.25$$

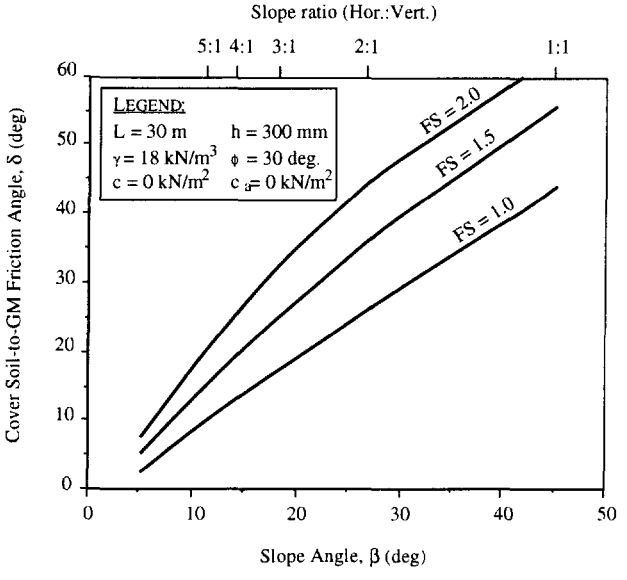


Figure 4. Design curves for stability of uniform thickness cohesionless cover soils on linear failure planes for various global factors-of-safety.

Comment:
In general, this is too low of a value for a final cover soil factor-of-safety and a redesign is necessary. While there are many possible options of changing the geometry of the situation, the example will be revisited later in this section using toe berms, tapered cover soil thickness and veneer reinforcement. Furthermore, this general problem will be used throughout the main body of this paper for comparison purposes to other cover soil slope stability situations.

3.2 Tracked Construction Equipment Forces

The placement of cover soil on a slope with a relatively low shear strength inclusion (like a geomembrane) should always be from the toe upward to the crest. Figure 5a shows the recommended method. In so doing, the gravitational forces of the cover soil and live load of the construction equipment are compacting previously placed soil and working with an ever present passive wedge and stable lower-portion beneath the active wedge. While it is necessary to specify low ground pressure equipment to place the soil, the reduction of the FS-value for this situation of equipment working up the slope will be seen to be relatively small.

For soil placement down the slope, however, a stability analysis cannot rely on toe buttressing and also a dynamic stress should be included in the calculation. These conditions decrease the FS-value and in some cases to a great extent. Figure 5b shows this procedure. Unless absolutely necessary, it is not recommended to place cover soil on a slope in this manner. If it is necessary, the design must consider the unsupported soil mass and the dynamic force of the specific type of construction equipment and its manner of operation.

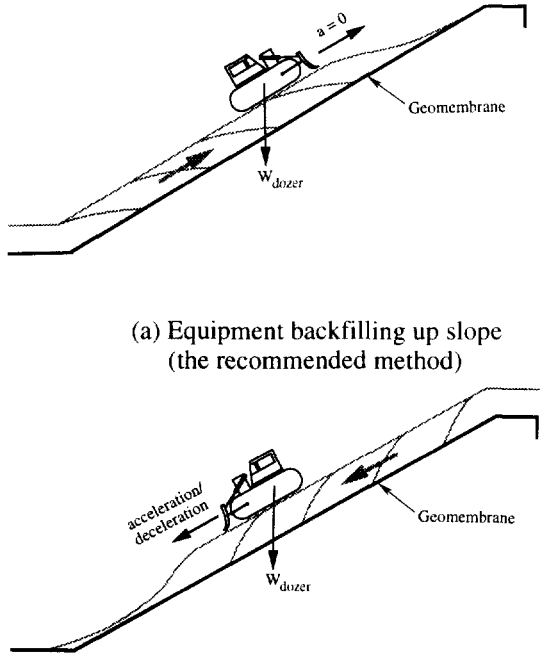


Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics.

For the first case of a bulldozer pushing cover soil up from the toe of the slope to the crest, the analysis uses the free body diagram of Figure 6a. The analysis uses a specific piece of tracked construction equipment (like a bulldozer characterized by its ground contact pressure) and dissipates this force or stress through the cover soil thickness to the surface of the geomembrane. A Boussinesq analysis is used, see Poulos and Davis (1974). This results in an equipment force per unit width as follows:

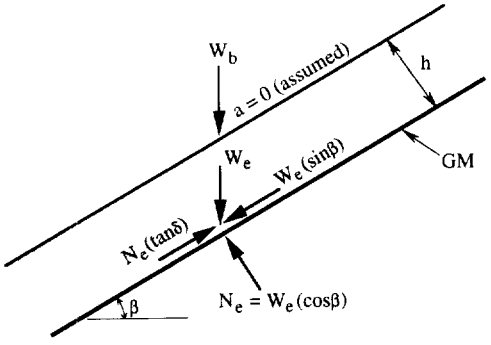
$$W_e = qwI \qquad (16)$$

where

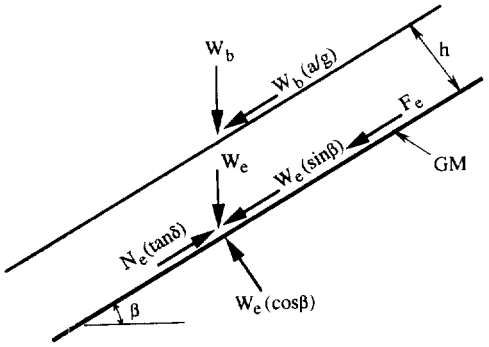
W_e = equivalent equipment force per unit width at the geomembrane interface

$q = W_b / (2 \times w \times b)$

W_b = actual weight of equipment (e.g., a bulldozer)
w = length of equipment track
b = width of equipment track
I = influence factor at the geomembrane interface see Figure 7



(a) Equipment moving up slope
(load with no assumed acceleration)



(b) Equipment moving down slope
(load plus acceleration or deceleration)

Figure 6. Additional (to gravitational forces) limit equilibrium forces due to construction equipment moving on cover soil (see Figure 3 for the gravitational soil force to which the above forces are added).

Upon determining the additional equipment force at the cover soil-to-geomembrane interface, the analysis proceeds as described in Section 3.1 for gravitational forces only. In essence, the equipment moving up the slope adds an additional term, W_e, to the W_A-force in Eq. 3. Note, however, that this involves the generation of a resisting force as well. Thus, the net effect of increasing the driving force as well as the resisting force is somewhat neutralized insofar as the resulting FS-value is concerned. It should also be noted that no acceleration/deceleration forces are included in this analysis which is somewhat optimistic. Using these concepts (the same equations used in Section 3.1 are used here), typical design curves for various FS-values as a function of equivalent ground contact equipment pressures and cover soil thicknesses are given in Figure 8. Note that the curves are developed specifically for the variables stated in the legend. Example 2a illustrates the use of the formulation.

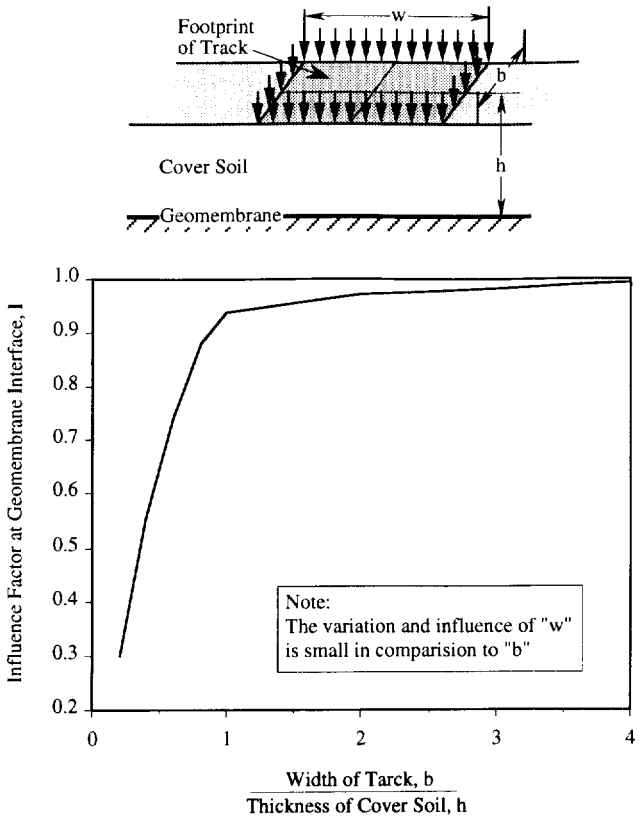


Figure 7. Values of influence factor, "I", for use in Eq. 16 to dissipate surface force of tracked equipment through the cover soil to the geomembrane interface, after Poulos and Davis (1974).

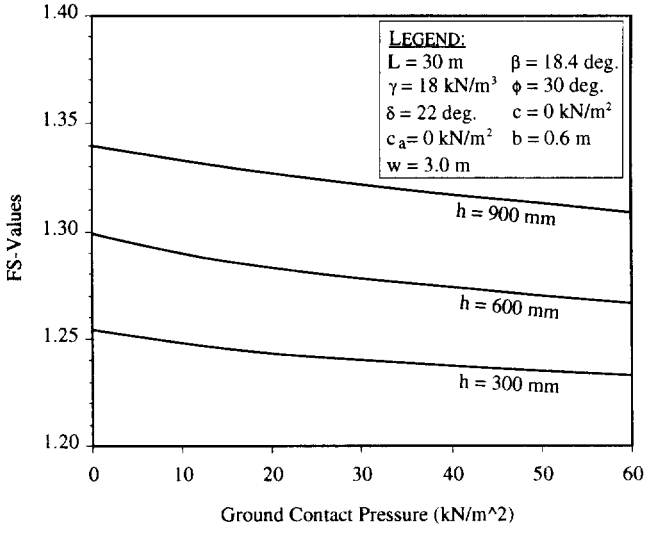


Figure 8. Design curves for stability of different thickness of cover soil for various values of tracked ground contact pressure construction equipment.

Example 2a:

Given 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the toe of the slope up to the crest. The bulldozer has a ground pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:
This problem follows Example 1 exactly except for the addition of the bulldozer moving up the slope. Using the additional equipment load Eq. 16, substituted into Eqs. 14 and 15 results in the following.

$$\left.\begin{aligned} a &= 73.1\,\text{kN/m} \\ b &= -104.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.24$$

Comment:
While the resulting FS-value is low, the result is best assessed by comparing it to Example 1, i.e., the same problem except without the bulldozer. It is seen that the FS-value has only decreased from 1.25 to 1.24. Thus, in general, a low ground contact pressure bulldozer placing cover soil up the slope with negligible acceleration/ deceleration forces does not significantly decrease the factor-of-safety.

For the second case of a bulldozer pushing cover soil down from the crest of the slope to the toe as shown in Figure 5b, the analysis uses the force diagram of Figure 6b. While the weight of the equipment is treated as just described, the lack of a passive wedge along with an additional force due to acceleration (or deceleration) of the equipment significantly changes the resulting FS-values. This analysis again uses a specific piece of construction equipment operated in a specific manner. It produces a force parallel to the slope equivalent to W_b (a/g), where W_b = the weight of the bulldozer, a = acceleration of the bulldozer and g = acceleration due to gravity. Its magnitude is equipment operator dependent and related to both the equipment speed and time to reach such a speed, see Figure 9. A similar behavior will be seen for deceleration.

The acceleration of the bulldozer, coupled with an influence factor "I" from Figure 7, results in the dynamic force per unit width at the cover soil to geomembrane interface, "F_e". The relationship is as follows:

$$F_e = W_e\left(\frac{a}{g}\right) \qquad (17)$$

where

F_e = dynamic force per unit width parallel to the slope at the geomembrane interface,

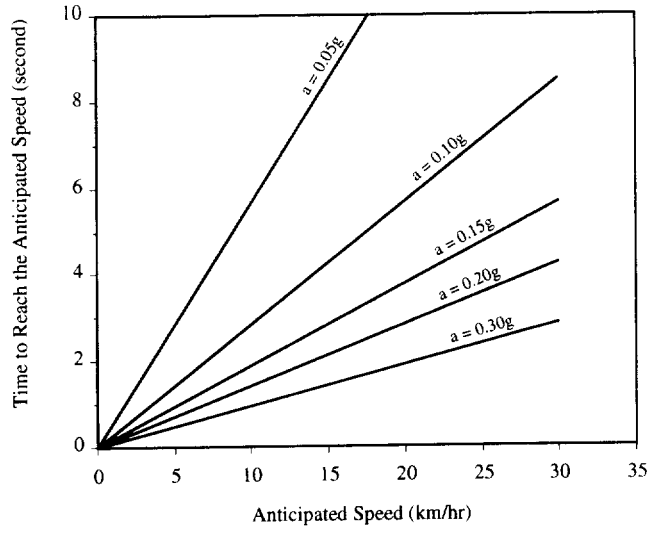


Figure 9. Graphic relationship of construction equipment speed and rise time to obtain equipment acceleration.

W_e = equivalent equipment (bulldozer) force per unit width at geomembrane interface, recall Eq. 16.
β = soil slope angle beneath geomembrane
a = acceleration of the bulldozer
g = acceleration due to gravity

Using these concepts, the new force parallel to the cover soil surface is dissipated through the thickness of the cover soil to the interface of the geomembrane. Again, a Boussinesq analysis is used, see Poulos and Davis (1974). The expression for determining the FS-value can now be derived as follows:

Considering the active wedge, and balancing the forces in the direction parallel to the slope, the following formulation results:

$$E_A + \frac{(N_e + N_A)\tan\delta + C_a}{FS} = (W_A + W_e)\sin\beta + F_e \qquad (18)$$

where

N_e = effective equipment force normal to the failure plane of the active wedge
= $W_e \cos\beta$ (19)

Note that all the other symbols have been previously defined.

The interwedge force acting on the active wedge can down be expressed as:

$$E_A = \frac{(FS)\left[(W_A + W_e)\sin\beta + F_e\right]}{FS} - \frac{\left[(N_e + N_A)\tan\delta + C_a\right]}{FS} \qquad (20)$$

The passive wedge can be treated in a similar manner. The following formulation of the interwedge force acting on the passive wedge results:

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \qquad (21)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of Eq. 13 in which the "a", "b" and "c" terms are as follows:

$$a = \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\cos\beta$$

$$b = -\left\{\left[\left(N_e + N_A\right)\tan\delta + C_a\right]\cos\beta + \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\sin\beta\tan\phi + \left(C + W_P\tan\phi\right)\right\}$$

$$c = \left[\left(N_e + N_A\right)\tan\delta + C_a\right]\sin\beta\tan\phi \qquad (22)$$

Finally, the resulting FS-value can be obtained using Eq. 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed, see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b:

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/hr and the time to reach this speed is 3.0 sec. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Using the design curves of Figure 10 along with Eqs. 22 substituted into Eq. 15 the solution can be obtained:

- From Figure 9 at 20 km/hr and 3.0 sec. the bulldozer's acceleration is 0.19g.
- From Eq. 22 substituted into Eq. 15 we obtain

$$\left.\begin{aligned} a &= 88.8\,\text{kN/m} \\ b &= -107.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.03$$

Comment:

This problem solution can now be compared to the previous two examples:

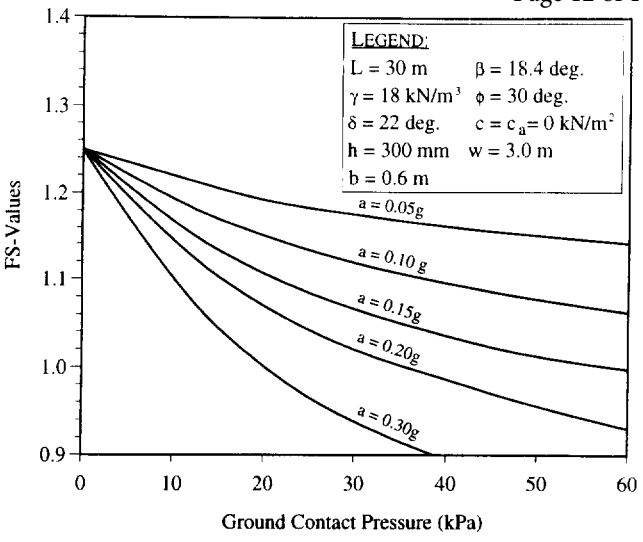


Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations.

Ex. 1:	cover soil alone with no bulldozer loading	FS = 1.25
Ex. 2a:	cover soil plus bulldozer moving up slope	FS = 1.24
Ex. 2b:	cover soil plus bulldozer moving down slope	FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note, that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp breaking action of the bulldozer is arguable the more severe condition due to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation and the construction specifications should reflect the exact conditions made in the design. The maximum allowable weight and ground contact pressure of the equipment should be stated along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses and should be avoided unless adequately designed. Additional detail is given in McKelvey (1994). The issue of access ramps is a unique subset of this example and one which deserves focused attention due to the high loads and decelerations that often occur.

3.3 Consideration of Seepage Forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely way from the cross section. The amount of water to be removed is obviously a site specific situation. Note that in extremely

$$E_P = \frac{C + W_P \tan\phi}{\cos\beta(FS) - \sin\beta\tan\phi} \qquad (21)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of Eq. 13 in which the "a", "b" and "c" terms are as follows:

$$a = \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\cos\beta$$

$$b = -\left\{\left[\left(N_e + N_A\right)\tan\delta + C_a\right]\cos\beta + \left[\left(W_A + W_e\right)\sin\beta + F_e\right]\sin\beta\tan\phi + \left(C + W_P\tan\phi\right)\right\}$$

$$c = \left[\left(N_e + N_A\right)\tan\delta + C_a\right]\sin\beta\tan\phi \qquad (22)$$

Finally, the resulting FS-value can be obtained using Eq. 15. Using these concepts, typical design curves for various FS-values as a function of equipment ground contact pressure and equipment acceleration can be developed, see Figure 10. Note that the curves are developed specifically for the variables stated in the legend. Example 2b illustrates the use of the formulation.

Example 2b:

Given a 30 m long slope with uniform cover soil of 300 mm thickness at a unit weight of 18 kN/m^3. The soil has a friction angle of 30 deg. and zero cohesion, i.e., it is a sand. It is placed on the slope using a bulldozer moving from the crest of the slope down to the toe. The bulldozer has a ground contact pressure of 30 kN/m^2 and tracks that are 3.0 m long and 0.6 m wide. The estimated equipment speed is 20 km/hr and the time to reach this speed is 3.0 sec. The cover soil to geomembrane friction angle is 22 deg. with zero adhesion. What is the FS-value at a slope angle of 3(H)-to-1(V), i.e., 18.4 deg.

Solution:

Using the design curves of Figure 10 along with Eqs. 22 substituted into Eq. 15 the solution can be obtained:

- From Figure 9 at 20 km/hr and 3.0 sec. the bulldozer's acceleration is 0.19g.
- From Eq. 22 substituted into Eq. 15 we obtain

$$\left.\begin{aligned} a &= 88.8\,\text{kN/m} \\ b &= -107.3\,\text{kN/m} \\ c &= 17.0\,\text{kN/m} \end{aligned}\right\} \quad FS = 1.03$$

Comment:

This problem solution can now be compared to the previous two examples:

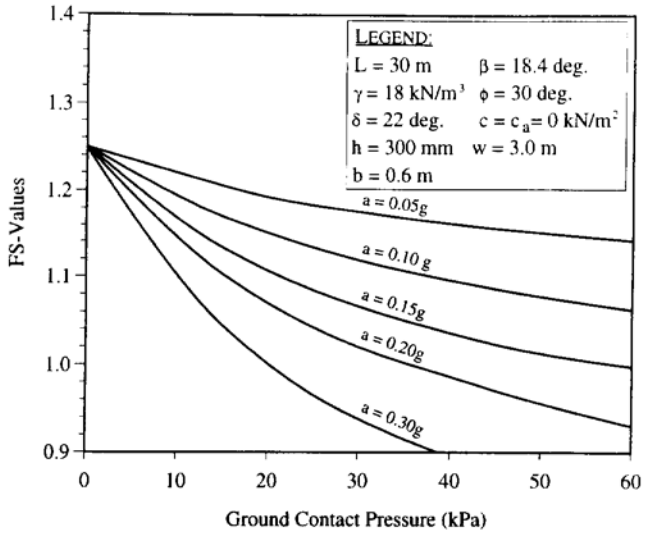


Figure 10. Design curves for stability of different construction equipment ground contact pressure for various equipment accelerations.

Ex. 1:	cover soil alone with no bulldozer loading	FS = 1.25
Ex. 2a:	cover soil plus bulldozer moving up slope	FS = 1.24
Ex. 2b:	cover soil plus bulldozer moving down slope	FS = 1.03

The inherent danger of a bulldozer moving down the slope is readily apparent. Note, that the same result comes about by the bulldozer decelerating instead of accelerating. The sharp breaking action of the bulldozer is arguable the more severe condition due to the extremely short times involved when stopping forward motion. Clearly, only in unavoidable situations should the cover soil placement equipment be allowed to work down the slope. If it is unavoidable, an analysis should be made of the specific stability situation and the construction specifications should reflect the exact conditions made in the design. The maximum allowable weight and ground contact pressure of the equipment should be stated along with suggested operator movement of the cover soil placement operations. Truck traffic on the slopes can also give as high, or even higher, stresses and should be avoided unless adequately designed. Additional detail is given in McKelvey (1994). The issue of access ramps is a unique subset of this example and one which deserves focused attention due to the high loads and decelerations that often occur.

3.3 Consideration of Seepage Forces

The previous sections presented the general problem of slope stability analysis of cover soils placed on slopes under different conditions. The tacit assumption throughout was that either permeable soil or a drainage layer was placed above the barrier layer with adequate flow capacity to efficiently remove permeating water safely way from the cross section. The amount of water to be removed is obviously a site specific situation. Note that in extremely

arid areas, or with very low permeability cover soils drainage may not be required although this is generally the exception.

Unfortunately, adequate drainage of final covers has sometimes not been available and seepage induced slope stability problems have occurred. The following situations have resulted in seepage induced slides:

- Drainage soils with hydraulic conductivity (permeability) too low for site specific conditions.
- Inadequate drainage capacity at the toe of long slopes where seepage quantities accumulate and are at their maximum.
- Fines from quarried drainage stone either clogging the drainage layer or accumulating at the toe of the slope thereby decreasing the as-constructed permeability over time.
- Fine, cohesionless, cover soil particles migrating through the filter (if one is present) either clogging the drainage layer, or accumulating at the toe of the slope thereby decreasing the as-constructed outlet permeability over time.
- Freezing of the drainage layer at the toe of the slope, while the soil covered top of the slope thaws, thereby mobilizing seepage forces against the ice wedge at the toe.

If seepage forces of the types described occur, a variation in slope stability design methodology is required. Such an analysis is the focus of this subsection. Note that additional discussion is given in Cancelli and Rimoldi (1989), Thiel and Stewart (1993) and Soong and Koerner (1996).

Consider a cover soil of uniform thickness placed directly above a geomembrane at a slope angle of "β" as shown in Figure 11. Different from previous examples, however, is that within the cover soil exists a saturated soil zone for part or all of the thickness. The saturated boundary is shown as two possibly different phreatic surface orientations. This is because seepage can be built-up in the cover soil in two different ways: a horizontal buildup from the toe upward or a parallel-to-slope buildup outward. These two hypotheses are defined and quantified as a horizontal submergence ratio (HSR) and a parallel submergence ratio (PSR). The dimensional definitions of both ratios are given in Figure 11.

When analyzing the stability of slopes using the limit equilibrium method, free body diagrams of the passive and active wedges are taken with the appropriate forces (now including pore water pressures) being applied. The formulation for the resulting factor-of-safety, for horizontal seepage buildup and then for parallel-to-slope seepage buildup, follows.

The Case of the Horizontal Seepage Buildup. Figure 12 shows the free body diagram of both the active and passive wedge assuming horizontal seepage. Horizontal seepage buildup can occur when toe blockage occurs due to inadequate outlet capacity, contamination or physical blocking of outlets, or freezing conditions at the outlets.

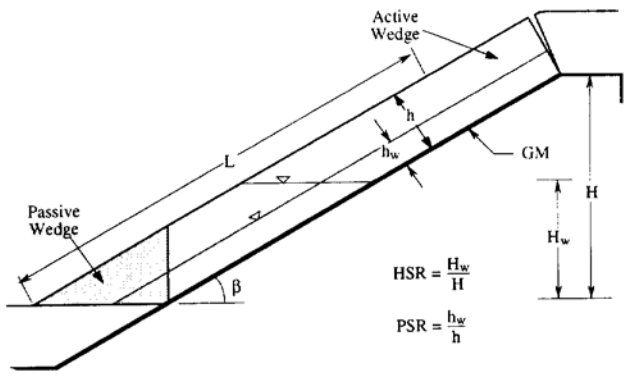


Figure 11. Cross section of a uniform thickness cover soil on a geomembrane illustrating different submergence assumptions and related definitions, Soong and Koerner (1996).

All symbols used in Figure 12 were previously defined except the following:

$\gamma_{sat'd}$ = saturated unit weight of the cover soil
γ_t = total (moist) unit weight of the cover soil
γ_w = unit weight of water
H = vertical height of the slope measured from the toe
H_w = vertical height of the free water surface measured from the toe
U_h = resultant of the pore pressures acting on the interwedge surfaces
U_n = resultant of the pore pressures acting perpendicular to the slope
U_v = resultant of the vertical pore pressures acting on the passive wedge

The expression for finding the factor-of-safety can be derived as follows:

Considering the active wedge,

$$W_A = \left(\frac{\gamma_{sat'd}(h)(2H_w\cos\beta - h)}{\sin 2\beta}\right) + \left(\frac{\gamma_t(h)(H - H_w)}{\sin\beta}\right) \quad (23)$$

$$U_n = \frac{\gamma_w(h)(\cos\beta)(2H_w\cos\beta - h)}{\sin 2\beta} \quad (24)$$

$$U_h = \frac{\gamma_w h^2}{2} \quad (25)$$

$$N_A = W_A(\cos\beta) + U_h(\sin\beta) - U_n \quad (26)$$

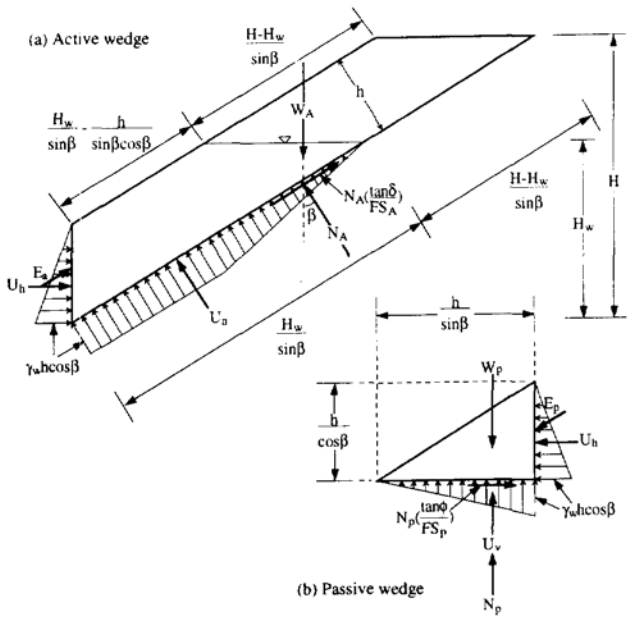


Figure 12. Limit equilibrium forces involved in a finite length slope of uniform cover soil with horizontal seepage buildup.

The interwedge force acting on the active wedge can then be expressed as:

$$E_A = W_A \sin\beta - U_h \cos\beta - \frac{N_A \tan\delta}{FS} \qquad (27)$$

The passive wedge can be considered in a similar manner and the following expressions result:

$$W_P = \frac{\gamma_{sat'} d h^2}{\sin 2\beta} \qquad (28)$$

$$U_V = U_h \cot\beta \qquad (29)$$

The interwedge force acting on the passive wedge can then be expressed as:

$$E_P = \frac{U_h(FS) - (W_P - U_V)\tan\phi}{\sin\beta\tan\phi - \cos\beta(FS)} \qquad (30)$$

By setting $E_A = E_P$, the following equation can be arranged in the form of $ax^2 + bx + c = 0$ which in this case is:

$$a(FS)^2 + b(FS) + c = 0 \qquad (13)$$

where

$$a = W_A \sin\beta\cos\beta - U_h \cos^2\beta + U_h$$

$$b = -W_A \sin^2\beta\tan\phi + U_h \sin\beta\cos\beta\tan\phi - N_A \cos\beta\tan\delta - (W_P - U_V)\tan\phi$$

$$c = N_A \sin\beta\tan\delta\tan\phi \qquad (31)$$

As with previous solution, the resulting FS-value is obtained using Eq. 15.

The Case of Parallel-to-Slope Seepage Buildup. Figure 13 shows the free body diagrams of both the active and passive wedges with seepage buildup in the direction parallel to the slope. Parallel seepage buildup can occur when soils placed above a geomembrane are initially too low in their hydraulic conductivity, or become too low due to long-term clogging from overlying soils which do not have a filter. Identical symbols as defined in the previous cases are used here with an additional definition of h_w equal to the height of free water surface measured in the direction perpendicular to the slope.

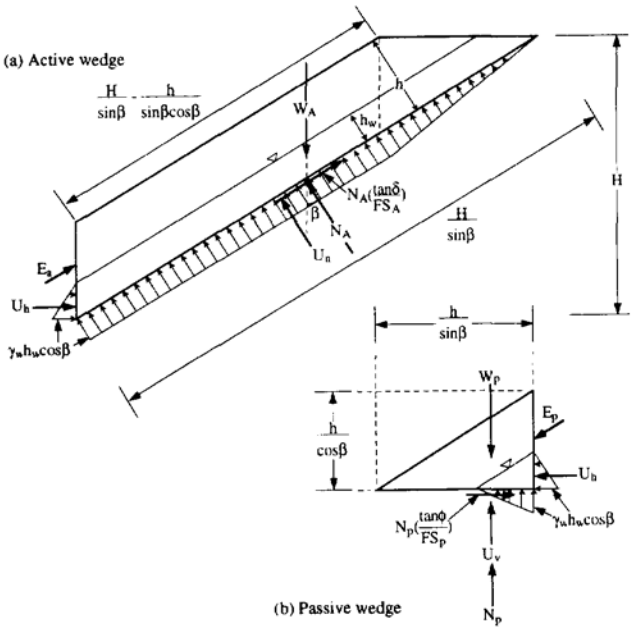


Figure 13. Limit equilibrium forces involved in a finite length slope of uniform cover soil with parallel-to-slope seepage buildup.

Note that the general expression of factor-of-safety shown in Eq. 15 is still valid. However, the a, b and c terms given in Eq. 31 have different definitions in this case owing to the new definitions of the following terms:

GROUND PRESSURES

Pressures computed from operating weights given earlier in this section in the specifications tables.

MODEL	SHOE WIDTH		CONTACT AREA		GROUND PRESSURE	
	mm	in	m²	in²	kPa	psi
D3C Series III	406	16	1.54	2390	44.7	6.49
D3C Hystat	406	16	1.54	2390	45.2	6.56
D3C XL Series III	406	16	1.67	2586	42.5	6.16
D3C XL Hystat	406	16	1.67	2586	42.9	6.23
D3C LGP Series III	635	25	2.61	4045	28.7	4.16
D3C LGP Hystat	635	25	2.61	4045	29.0	4.20
D4C Series III	406	16	1.67	2586	42.7	6.19
D4C Hystat	406	16	1.67	2586	43.0	6.25
D4C XL Series III	457	18	2.02	3131	36.2	5.25
D4C XL Hystat	457	18	2.02	3131	36.5	5.29
D4C LGP Series III	635	25	2.61	4045	29.0	4.21
D4C LGP Hystat	635	25	2.61	4045	29.2	4.24
D5C Series III	457	18	1.96	3039	42.1	6.11
D5C Hystat	457	18	1.96	3039	42.4	6.16
D5C XL Series III	508	20	2.35	3547	36.5	5.30
D5C XL Hystat	508	20	2.35	3547	36.7	5.33
D5C LGP Series III	660	26	2.83	4389	30.8	4.48
D5C LGP Hystat	660	26	2.83	4389	31.1	4.51
D5M XL ◀	510	20	2.44	3775	48	6.83
	560	22	2.67	4146	44	6.22
D5M LGP	610	24	3.18	4922	40	5.64
◀	760	30	3.96	6133	32	4.53
	770	30	4.01	6213	31	4.47
D5E	406	16	1.77	2745	62	9.00
◀	457	18	1.99	3085	55	7.98
D6M XL	560	22	2.89	4427	52	7.49
◀	600	24	3.06	4743	48	6.99
D6M LGP	710	28	4.38	6783	37	5.36
◀	860	34	5.30	8217	31	4.43
	865	34	5.33	8264	30	4.40
D6G	457	18	2.43	3766	60	8.70
◀	508	20	2.71	4200	54	7.83
	560	22	2.98	4619	49	7.10
	610	24	3.25	5040	45	6.54
D6R ◀	560	22	2.92	4518	61	8.82
	610	24	3.18	4930	56	8.14

◀ Standard Shoe.

MODEL	SHOE WIDTH		CONTACT AREA		GROUND PRESSURE	
	mm	in	m²	in²	kPa	psi
D6R XL ◀	560	22	3.16	4888	60	8.60
	610	24	3.44	5332	55	7.93
D6R XL (IG)	762	30	4.30	6696	44	6.50
D6R XR ◀	560	22	3.08	4770	60	8.68
	610	24	3.36	5203	56	8.01
D6R LGP	760	30	4.93	7662	41	5.80
◀	915	36	5.93	9194	35	4.94
	1000	39	6.49	9961	32	4.55
D7G ◀	508	20	2.76	4280	73	10.60
◀	559	22	3.04	4708	66	9.60
	610	24	3.31	5136	60	8.80
D7R	510	20	2.94	4560	82	11.71
◀	560	22	3.24	5016	75	10.69
	610	24	3.53	5472	69	9.87
	660	26	3.82	5928	64	9.17
D7R XR	560	22	3.43	5315	71.5	10.16
◀	610	24	3.75	5808	65.9	9.37
	660	26	4.06	6282	61.2	8.70
D7R LGP	760	30	4.80	7504	54	7.74
	915	36	5.82	9029	46	6.55
D8R ◀	560	22	3.59	5565	101.1	14.67
	610	24	3.91	6062	92.8	13.47
	660	26	4.23	6559	85.9	12.47
	710	28	4.55	7056	79.7	11.57
D8R LGP	965	38	6.20	9576	58.6	8.50
D9R	560	22	3.86	6009	121.1	17.58
◀	610	24	4.24	6569	110.8	16.08
	685	27	4.74	7374	98.7	14.32
	760	30	5.26	8194	88.8	12.89
D10R ◀	610	24	4.73	7326	136.4	19.79
	710	28	5.50	8527	117.1	17.00
	860	31.5	6.66	10,328	96.7	14.04
D11R ◀	710	28	6.31	9781	158.8	23.05
	810	32	7.20	11,159	139.2	20.21
	915	36	8.13	12,605	123.2	17.89

◀ Standard shoe.

NOTE: Ground contact area = width of track shoe × length of track on ground × 2.

$$\text{Ground pressure} = \frac{\text{operating weight}}{\text{ground contact area}}$$

Caterpillar Performance Handbook, Edition 29. Caterpillar.

Computed: LZ	Date: 08/15/19	KEY ENVIRONMENTAL INCORPORATED	Client: Earth Systems
Checked: CAZ	Date: 08/22/19		Project: North Landfarm
Project No.	19819 02		Page 1 of 5
SUBJECT: Geotextile Separation Layer Design, North Landfarm, Hess Corporation - Former Port Reading Refining Facility			
Middlesex County, Port Reading, NJ			

Purpose: Determine geotextile properties for separation applications for the North Landfarm Cap
(1) between coarse aggregate cover and common fill; and,
(2) between edge aggregate at toe and common fill.

Solution:

A Common fill, assume <50% passing No. 200 sieve
from Koerner 6th Edition, according to AASHTO [4], for soil with less than or equal to 50% passing the no. 200 sieve
O95 < 0.60 mm = 0.024 inch
AOS* >= No. 30 Sieve
* Apparent opening size

B Coarse Aggregate: No. 2 or No.3 NJDOT size (up to 3") placed on prepared common fill.
Based on GRI GT13(a) Table 3: Class 2 geotextile
Use Table 1(b) spec.

C Edge Aggregate: No.1 NJDOT size (up to 4") placed on existing grade in thin layer.
Based on GRI GT13(a) Table 3: Class 1 geotextile
Use Table 1(a) spec.

References:

1. Designing with Geosynthetics (6th Edition, Jan 16, 2012), Robert M. Koerner.
2. GRI GT13(a) - ASTM version. Standard specification for "Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate", Rev 4, Jun3 20, 2017.

geotextile's permeability to be some multiple of the adjacent soil's permeability—e.g., 0.1, 1.0 or 10.0 (see Christopher and Fisher [3]).

Soil Retention. For the required flow of liquid to be allowed through the geotextile, the void spaces in it must be sufficiently large. There is, however, a limit—that being when the upstream soil particles start to pass through the geotextile voids along with the flowing liquid. This can lead to an unacceptable situation called *soil piping*, in which soil particles are carried through the geotextile, leaving unstable soil voids behind. The velocity of the liquid then increases, accelerating the process, until the upstream soil structure begins to collapse. This collapse often leads to small sinkhole-type patterns that grow larger with time.

This process is prevented by making the geotextile voids tight enough to retain the soil on the upstream side of the fabric. It is the coarser soil fraction that must be initially retained and that is the targeted soil size in the design process. These coarser-sized particles eventually block the finer-sized particles from moving and build up a stable upstream soil structure. In a sense, the geotextile is acting as a catalyst to make the upstream soil do its own filtration. Fortunately, filtration concepts are well established in the design of soil filters, and those same ideas will be used to design an adequate geotextile filter.

There are many formulas that can be applied to soil-retention design, most of which use the soil particle size characteristics and compare them to the 95% opening size of the geotextile, which is defined as the O_{95} value. The test method used in the United States to determine this value is called the *apparent opening size* (AOS) and is obtained using a dry-sieving method. In Europe and Canada, the test method is called *filtration opening size* (FOS) and is accomplished by wet or hydrodynamic sieving. Both of these latter methods are preferable to the dry-sieving method used in the United States, but there seems to be a reluctance to change.

The simplest of the design procedures examines the percentage of soil passing the no. 200 sieve, whose openings are 0.074 mm. According to AASHTO [4], the following is recommended:

- For soil with ≤ 50% passing the no. 200 sieve: $O_{95} < 0.60$ mm—i.e., AOS of the fabric ≥ no. 30 sieve.
- For soil > 50% passing the no. 200 sieve: $O_{95} < 0.30$ mm—i.e., AOS of the fabric ≥ no. 50 sieve

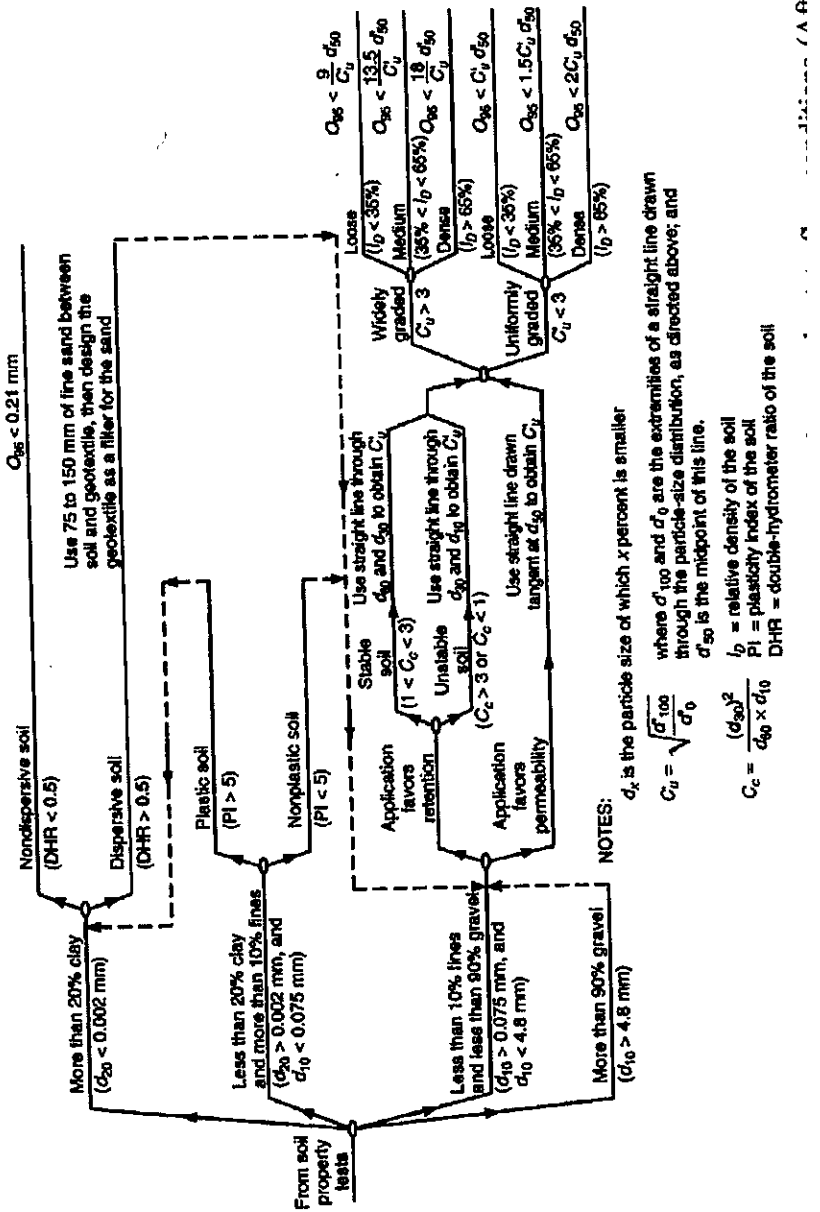


Table 901.03-1 Standard Sizes of Coarse Aggregate

		Amounts finer than each laboratory sieve, percentage by weight														
No.	Nominal Size	4"	3-1/2"	3"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 50	No. 100
1	3-1/2" - 1-1/2"	100	90-100		25-60		0-15		0-5							
2	2-1/2" - 1-1/2"			100	90-100	35-70	0-15		0-5							
3	2" - 1"				100	90-100	35-70	0-15		0-5						
4	1-1/2" - 3/4"					100	90-100	20-55	0-15		0-5					
5	1" - 1/2"						100	90-100	20-55	0-10	0-5					
57	1" - No. 4						100	95-100		25-60		0-10	0-5			
67	3/4" - No. 4							100	90-100		20-55	0-10	0-5			
7	1/2" - No. 4								100	90-100	40-70	0-15	0-5			
8	3/8" - No. 8									100	85-100	10-30	0-10	0-5		
9	No. 4 - No. 16										100	85-100	10-40	0-10	0-5	
10	No. 4 - No. 200										100	85-100				10-30

Table 901.03-2 Coarse Aggregate Sampling

Coarse Aggregate, No.	Sample Size (pounds)	Frequency
1	150	1000 tons or 830 cubic yards
2	100	1000 tons or 830 cubic yards
3	90	1000 tons or 830 cubic yards
4	70	1000 tons or 830 cubic yards
5 & 57	50	500 tons or 415 cubic yards
67	30	500 tons or 415 cubic yards
7	20	250 tons or 200 cubic yards
8, 9, & 10 (stone sand)	10	250 tons or 200 cubic yards

901.03.01 Broken Stone

Use broken stone that is uniform in texture and quality and that conforms to the requirements specified in Table 901.03.01-1.

Table 901.03.01-1 Requirements for Broken Stone

Aggregate Property	Test Method	Maximum Percent
Weathered and deleterious stone	NJDOT A-3	5
Broken stone other than that classification approved for use	NJDOT A-3	5
Flat and elongated pieces for graded material No. 67 and larger (length greater than 5 times the thickness or width)	ASTM D 4791	10
Absorption in cold water:		
No. 9 and larger	AASHTO T 85	1.8
Stone sand only (No. 10)	AASHTO T 84	2.0
Sodium sulfate soundness, loss	AASHTO T 104	10
Adherent fines in coarse aggregates:		
HMA	NJDOT A-4	1.5
Concrete	NJDOT A-4	1.0
Percentage of wear (Los Angeles Abrasion Test):		
HMA surface course	AASHTO T 96	40
HMA intermediate or base course	AASHTO T 96	45
Concrete surface course and bridge decks	AASHTO T 96	40
Concrete, other	AASHTO T 96	50
Dense-graded aggregate base course	AASHTO T 96	50

Table 3 - Required Degree of Survivability as a Function of Subgrade Conditions, Construction Equipment and Lift Thickness
(Class 1, 2 and 3 Properties are Given in Table 1 and 2; Class 1 + Properties are Higher than Class 1 but Not Defined at this Time)

	Low ground-pressure equipment ≤ 25 kPa (3.6 psi)	Medium ground-pressure equipment > 25 to ≤ 50 kPa (>3.6 to ≤ 7.3 psi)	High ground-pressure equipment > 50 kPa (> 7.3 psi)
Subgrade has been cleared of all obstacles except grass, weeds, leaves, and fine wood debris. Surface is smooth and level so that any shallow depressions and humps do not exceed 450 mm (18 in.) in depth or height. All larger depressions are filled. Alternatively, a smooth working table may be placed.	Low (Class 3)	Moderate (Class 2)	High (Class 1)
Subgrade has been cleared of obstacles larger than small to moderate-sized tree limbs and rocks. Tree trunks and stumps should be removed or covered with a partial working table. Depressions and humps should not exceed 450 mm (18 in.) in depth or height. Larger depressions should be filled.	Moderate (Class 2)	High (Class 1)	Very High (Class 1+)
Minimal site preparation is required. Trees may be felled, delimbed, and left in place. Stumps should be cut to project not more than ± 150 mm (6 in.) above subgrade. Fabric may be draped directly over the tree trunks, stumps, large depressions and humps, holes, stream channels, and large boulders. Items should be removed only if placing the fabric and cover material over them will distort the finished road surface.	High (Class 1)	Very high (Class 1+)	Not recommended

*Recommendations are for 150 to 300 mm (6 to 12 in.) initial lift thickness. For other initial lift thicknesses:
300 to 450 mm (12 to 18 in.): reduce survivability requirement one level;
450 to 600 mm (18 to 24 in.): reduce survivability requirement two levels;
> 600 mm (24 in.): reduce survivability requirement three levels

Note 1: While separation occurs in every geotextile application, this pavement-related specification focuses on subgrade soils being "firm" as indicated by CBR values higher than 3.0 (soaked) or 8.0 (unsoaked).

Source: Modified after Christopher, Holtz, and DiMaggio

English Units

Table 1(a) – Geotextile Properties Class 1 (High Survivability)

← for NJDOT No. 1 coarse aggregate

Property[1]	ASTM Test	Unit	Elongation < 50%	Elongation ≥ 50%
Grab Tensile Strength	D 4632	lb	315	203
Trapezoid Tear Strength	D 4533	lb	112	79
CBR Puncture Strength	D 6241	lb	630	440
Permittivity	D 4491	sec-1	0.02	0.02
Apparent Opening Size	D 4751	in.	0.024	0.024
Ultraviolet Stability[2]	D 7238	% Str. Ret. @ 500 lt. hrs.	80	80

Table 1(b) – Geotextile Properties Class 2 (Moderate Survivability)

← for NJDOT No. 2 or 3 coarse aggregate

Property[1]	ASTM Test	Unit	Elongation < 50%	Elongation ≥ 50%
Grab Tensile Strength	D 4632	lb	248	158
Trapezoid Tear Strength	D 4533	lb	90	56
CBR Puncture Strength	D 6241	lb	500	320
Permittivity	D 4491	sec-1	0.02	0.02
Apparent Opening Size	D 4751	in.	0.024	0.024
Ultraviolet Stability[2]	D 7238	% Str. Ret. @ 500 lt. hrs.	70	70

Table 1(c) – Geotextile Properties Class 3 (Low Survivability)

Property[1]	ASTM Test	Unit	Elongation < 50%	Elongation ≥ 50%
Grab Tensile Strength	D 4632	lb	180	113
Trapezoid Tear Strength	D 4533	lb	68	41
CBR Puncture Strength	D 6241	lb	380	230
Permittivity	D 4491	sec-1	0.02	0.02
Apparent Opening Size	D 4751	in.	0.024	0.024
Ultraviolet Stability[2]	D 7238	% Str. Ret. @ 500 lt. hrs.	60	60

Notes:

(1) All values are minimum average roll values (MARV) except AOS which is a maximum average roll value (MaxARV) and UV stability which is a minimum average value.

(2) Evaluation to be on 50 mm strip tensile specimens after 500 hours exposure.

Geosynthetic Research Institute, 2017. GRI GT-13(a) "Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate" (Rev 4). June 20.

Computed: LZ Date: 08/15/19
Checked: CAZ Date: 08/22/19

KEY ENVIRONMENTAL INCORPORATED

Client: Earth Systems
Project No.: 19819 02

Universal Soil Loss
Soil Remedial Action Design
AOC-1: North Landfarm
Hess Corporation – Former Port Reading Refining Facility
Port Reading, Middlesex County, New Jersey

Problem Statement

Evaluate erosion potential and sediment yields of the North Landfarm Final Cover.

Approach

The average annual soil loss in tons per acre per year is determined using the Revised Universal Soil Loss Equation which is as follows:

$$E = R * K * LS * C * P$$

where:

E = Average Annual Soil Loss (tons/acre/year)
R = Rainfall and Runoff Erosivity Factor
K = Soil Erodibility Factor (tons/acre)
LS = Slope Length and Steepness Factor
C = Cover Management Factor
P = Practice Factor

The USEPA recommends that soil loss be less than 2 tons per acre (ref. 1). If the soil loss is greater than 2 tons per acre, diversion or other erosion control features should be incorporated into the design to limit erosion.

Assumptions

Assume the following values for each of the soil loss equation factors (ref. 2):

R	K	LS		C		P
200	0.2	0.40	(4% slope)	0.02	(crushed stone)	1
200	0.2	4	(33.3% slope)	0.02	(crushed stone)	1

R = 200, Middlesex County, New Jersey, Figure A1-1, attached
K = 0.2 (1)
LS = Table A1-3 attached
Longest length is 101 feet at a 4% slope condition: LS is 0.40
Longest length is 19 feet at slope 3H:1V condition: LS is 4.

C = 0.02, Table A1-4, [crushed stone (1/4" to 1 ½ ") applied at 240 tons/acre]
P = Held at unity to represent no design terraces or contouring

(1) Assumed the protection layer to be coarse textured soils. According to RUSLE Handbook prepared by the USDA RUSLE Development Team, coarse textured soils, such as sandy soils, have low K values, about 0.05 to 0.2, because of low runoff even though these soils are easily detached.

Results

E (ton/acre/year)	Slope	Area (acre)	Erosion from subarea (ton/year)	Erosion from entire site (ton/year)	Weighted E (ton/acre/year)
0.32	4%	0.35	0.11	0.14	0.4
3.2	33.3%	0.01	0.03		

Conclusions

As shown in the above table, the weighted soil loss for the North Landfarm site will be less than USEPA's 2.0 tons/acre criteria based on conservative estimates for the erodibility of soil under coarse aggregate cover.

References

1. U.S. Environmental Protection Agency, 1989. Technical Guidance Document: Final Covers on Hazardous Waste Landfills and Landfills and Surface Impoundments. EPA/530/SW-89/047. July.
2. New Jersey Department of Agriculture – State Soil Conservation Committee, 2017. The Standards for Soil Erosion and Sediment Control in New Jersey (7th edition, January 2014; Revised July 2017). July. https://nj.gov/agriculture/divisions/anr/pdf/2014secappendices.pdf.
3. Key Environmental, Inc., 2019. Design Drawings titled "Soil Remedial Action Design, AOC-1: North Landfarm, Hess Corporation – Former Port Reading Refining Facility, Port Reading, Middlesex County, New Jersey". August.

FIGURE A1-1

RAINFALL EROSION VALUES "R"

NEW JERSEY MAP

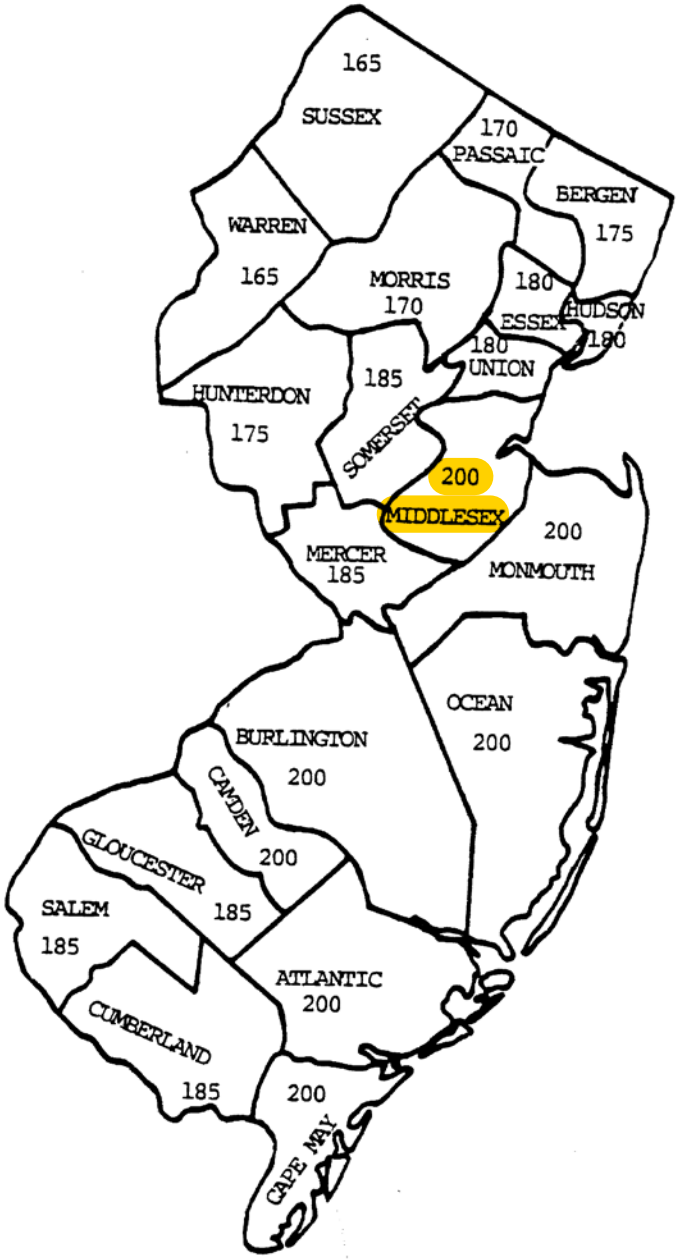


TABLE A1-3

VALUES OF THE TOPOGRAPHIC FACTOR "LS"

Length of Slope (L) Ft.	Percent Slope (S) 0.2	0.3	0.4	0.5	1.0	2.0	3.0	4.0	5.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0	25.0	30.0	40.0	50.0	60.0
20	.05	.05	.06	.06	.08	.12	.18	.21	.24	.30	.44	.61	.81	1.0	1.3	1.6	1.8	2.6	4	6	8	10
40	.06	.07	.07	.08	.10	.15	.22	.28	.34	.43	.63	.87	1.2	1.4	1.8	2.2	2.6	3.5	5	8	11	15
60	.07	.08	.08	.08	.11	.17	.25	.33	.41	.52	.77	1.0	1.4	1.8	2.2	2.6	3.0	4.5	6	10	14	18
80	.08	.08	.09	.09	.12	.19	.27	.37	.48	.60	.89	1.2	1.6	2.1	2.6	3.0	3.6	5.5	7	11	16	21
100	.08	.09	.09	.10	.13	.20	.29	.40	.54	.67	.99	1.4	1.8	2.4	2.9	3.5	4.2	6.0	8	13	18	23
110	.08	.09	.10	.10	.13	.21	.30	.42	.56	.71	1.0	1.5	2.0	2.5	3.0	3.7	4.5	6	9	14	19	25
120	.09	.09	.10	.10	.14	.21	.30	.43	.59	.74	1.0	1.6	2.1	2.6	3.3	4.0	4.6	7	9	14	20	26
130	.09	.09	.10	.11	.14	.22	.31	.44	.61	.77	1.2	1.6	2.2	2.8	3.4	4.1	4.9	7	9	15	20	27
140	.09	.10	.10	.11	.14	.22	.32	.46	.63	.80	1.2	1.7	2.3	2.9	3.6	4.3	5.1	7	10	15	21	29
150	.09	.10	.11	.11	.15	.23	.32	.47	.66	.82	1.2	1.8	2.4	3.0	3.7	4.5	5.3	8	10	16	23	30
160	.09	.10	.11	.11	.15	.23	.33	.48	.68	.85	1.2	1.9	2.5	3.1	3.9	4.7	5.5	8	10	17	24	31
180	.10	.10	.11	.12	.15	.24	.34	.51	.72	.90	1.4	1.9	2.6	3.3	4.1	5.0	6.0	9	12	18	26	33
200	.10	.11	.11	.12	.16	.25	.35	.53	.76	.95	1.4	2.1	2.8	3.6	4.4	5.3	6.3	9	12	18	27	35
300	.11	.12	.13	.14	.18	.28	.40	.62	.93	1.2	1.8	2.7	3.6	4.5	5.6	6.8	8	12	16	25	35	45
400	.12	.13	.14	.15	.20	.31	.44	.70	1.0	1.4	2.0	3.2	4.2	5.4	6.7	8.0	10	14	19	30	42	54
500	.13	.14	.15	.16	.21	.33	.47	.76	1.2	1.6	2.2	3.7	4.9	6.2	7.6	9.2	11	16	21	34	47	61
600	.14	.15	.16	.17	.22	.34	.49	.82	1.4	1.6	2.4	4.1	5.4	6.9	8.5	10.3	12	16	24	38	53	68
700	.15	.16	.17	.18	.23	.36	.52	.87	1.4	1.8	2.6	4.5	5.0	7.5	9.3	11.3	13	18	26	41	58	75
800	.15	.16	.17	.18	.24	.38	.54	.92	1.6	2.0	2.8	4.9	6.4	8.2	10.1	12.2	14	20	28	45	58	81
900	.16	.17	.18	.19	.25	.39	.56	.96	1.6	2.0	3.0	5.2	6.9	8.8	10.8	13.1	16	22	30	48	67	87
1000	.16	.18	.19	.20	.26	.40	.57	1.0	1.6	2.2	3.0	5.6	7.4	9.3	11.6	14.0	17	24	32	51	72	93

When the length of slope exceeds 400 feet and (or) percent of slope exceeds 24 percent, soil loss estimates are speculative as these values are beyond the range of research data.

Table A1-4

C Values and Slope-Length Limits for Various Mulches \1

Type	T/ac	Slope %	C Value	Max Length
1. No Mulch or Seeding	---	All	1.0	---
2. Straw or Hay tied	1.0	≤5	. .20	200
		6-10	.20	100
	1.5	≤5	.12	300
		6-10	.12	150
	2.0	≤5	.06	400
		6-10	.06	200
		11-15	.07	150
		16-20	.11	100
		21-25	.14	75
		26-33	.17	50
		34-50	.20	35
3. Crushed Stone (1/4"-1 1/2")	135	≤15	.05	200
		16-20	.05	150
		21-33	.05	100
		34-50	.05	75
	240	≤20	.02	300
		21-33	.02	200
		34-50	.02	150
4. Woodchips	7	≤15	.08	75
		16-20	.08	50
	12	≤15	.05	150
		16-20	.05	100
		21-33	.05	75
	25	≤15	.02	200
		16-20	.02	150
		21-33	.02	100
		34-50	.02	75

TABLE A1-5

PRACTICE FACTOR Pc FOR SURFACE CONDITION FOR CONSTRUCTION SITES

SURFACE CONDITION WITH NO COVER	FACTOR Pc*
Compact and smooth, scraped with bulldozer or scraper up and down hill	1.3
Same condition, except raked with bulldozer root rake up and down hill	1.2
Compact and smooth, scraped with bulldozer or scraper across the slope	1.2
Same condition, except raked with bulldozer root rake across the slope	0.9
Loose as a disced plow layer	1.0
Rough irregular surface equipment, tracks in all directions	0.9
Loose with rough surface greater than 12" depth	0.8
Loose with smooth surface greater than 12" depth	0.9

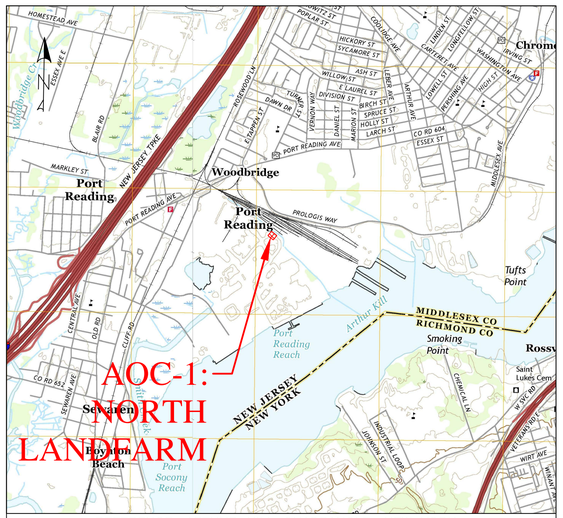
*Values based on estimates

APPENDIX C

DESIGN DRAWINGS

EARTH SYSTEMS, INC.

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

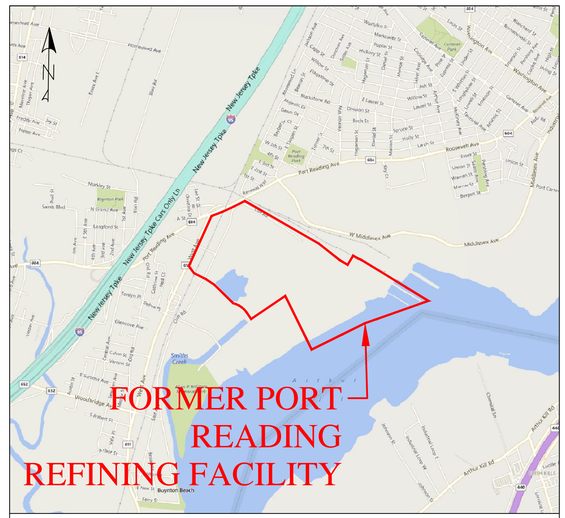


REFERENCE: ARTHUR KILL QUADRANGLE, NEW YORK–NEW JERSEY, 7.5 MINUTE SERIES, USGS, 2016

0 2000 4000 FEET

LOCATION MAP

DRAWING NO.	DRAWING TITLE
NLF-G-001	TITLE SHEET
NLF-G-002	GENERAL NOTES AND LEGEND
NLF-G-003	SOIL EROSION AND SEDIMENT CONTROL NOTES
NLF-C-101	EXISTING SITE CONDITIONS PLAN
NLF-C-102	SOIL EROSION AND SEDIMENT CONTROL PLAN
NLF-C-103	WORK AREA PLAN
NLF-C-104	SUBGRADE GRADING PLAN
NLF-C-105	FINAL GRADING PLAN
NLF-C-301	CROSS-SECTIONS
NLF-C-501	SOIL EROSION AND SEDIMENT CONTROL DETAILS
NLF-C-502	CAP DETAILS (SHEET 1 OF 2)
NLF-C-503	CAP DETAILS (SHEET 2 OF 2)
NLF-C-504	FENCE DETAILS (SHEET 1 OF 2)
NLF-C-505	FENCE DETAILS (SHEET 2 OF 2)



REFERENCE: GOOGLE EARTH NOVEMBER 5, 2015

0 2000 4000 FEET

VICINITY MAP

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY
ALAN E. BRIGGS
No. GE38785
PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: SCC	DATE: 08/14/19	KEY ENVIRONMENTAL INCORPORATED	
CHKD: LZ	DATE: 08/23/19		
APPD: AEB	DATE: 08/23/19		
SCALE:	AS SHOWN		

SOIL REMEDIAL ACTION DESIGN
AOC–1: NORTH LANDFARM
HESS CORPORATION–FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

TITLE SHEET

PROJECT NO: 19–819

NLF–G–001

GENERAL NOTES:

1. THE GENERAL NOTES APPLY TO ALL OF DRAWINGS IN THE DRAWING SET UNLESS OTHERWISE NOTED. NOTES ARE NOT REPEATED THROUGHOUT THE DRAWING SET TO IDENTIFY THE BASIS OF THE SAME INFORMATION.
2. GRID COORDINATES REFERENCE NEW JERSEY STATE PLANE COORDINATE SYSTEM, NORTH AMERICAN DATUM (NAD) OF 1983. ELEVATIONS REFERENCE NORTH AMERICAN VERTICAL DATUM 1988 (NAVD 88).
3. EXISTING TOPOGRAPHY AND PHYSICAL FEATURE LOCATIONS BASED ON APRIL 25, 2019 GROUND SURVEY PERFORMED BY DPK CONSULTING, LLC OF PISCATAWAY, NEW JERSEY.
4. AOC–1: NORTH LANDFARM LIMITS, AND CATCH BASINS AND ASSOCIATED SANITARY SEWER LINE LOCATED WITHIN AST 7945 SECONDARY CONTAINMENT DIKE, AND TOPOGRAPHY AND PHYSICAL FEATURE LOCATIONS OUTSIDE OF AST 7945 SECONDARY CONTAINMENT DIKE WERE OBTAINED FROM FIGURE 3 OF THE DOCUMENT TITLED "REMEDIAL ACTION WORKPLAN / POST–CLOSURE MONITORING PLAN" PREPARED BY EARTH SYSTEMS DATED SEPTEMBER 13, 2016. LOCATIONS SHOWN ARE APPROXIMATE.
5. SUBSURFACE FEATURE LOCATIONS SHOWN ARE APPROXIMATE AND ARE BASED ON EVIDENCE OBSERVED ON THE SURFACE ONLY AND REVIEW OF REFERENCE DRAWINGS. INDICATED UTILITIES MAY NOT COMPRISE ALL UTILITIES EITHER IN–SERVICE OR ABANDONED.
6. BASED ON EFFECTIVE FLOOD INSURANCE RATE MAP, MAP NUMBER 34023C0078F (FEDERAL EMERGENCY MANAGEMENT AGENCY, JULY 6, 2010), NORTH LANDFARM LIES WHOLLY OUTSIDE OF THE 100–YEAR BASE FLOOD ELEVATION (1–PERCENT ANNUAL CHANCE FLOOD), BUT INSIDE OF THE AREA OF MODERATE FLOOD HAZARD, WHICH INDICATES AN AREA THAT MAY BE PROVIDED FLOOD RISK REDUCTION DUE TO A FLOOD CONTROL SYSTEM OR AN AREA THAT IS PRONE TO FLOODING DURING A 0.2–PERCENT ANNUAL CHANCE STORM EVENT. THE 100–YEAR BASE FLOOD ELEVATION IS APPROXIMATELY 9 FEET NAVD 88 IN THE VICINITY OF THE SITE.
   BASED ON PRELIMINARY FLOOD INSURANCE RATE MAP, MAP NUMBER 34023C0078G (FEDERAL EMERGENCY MANAGEMENT AGENCY, JANUARY 30, 2015), NORTH LANDFARM LIES WHOLLY WITHIN THE 100–YEAR BASE FLOOD ELEVATION (1–PERCENT ANNUAL CHANCE FLOOD). THE 100–YEAR BASE FLOOD ELEVATION IS APPROXIMATELY 13 FEET NAVD 88 IN THE VICINITY OF THE SITE.
   NORTH LANDFARM LIES WHOLLY WITHIN THE AREA PRONE TO CATEGORY 1 STORM SURGE INUNDATION WITH INUNDATION HEIGHT UP TO 3 FEET ABOVE GROUND BASED ON THE NATIONAL STORM SURGE HAZARD MAPS.
7. FIGURED DIMENSIONS TAKE PRECEDENCE OVER SCALED DIMENSIONS. CHECK GRAPHIC SCALE BEFORE SCALING DRAWING.
8. LIMIT OF DISTURBANCE INDICATED IN THIS DRAWING SET IS PROVIDED FOR CLARITY ONLY. LIMIT OF DISTURBANCE AND EROSION AND SEDIMENT CONTROL BMPS SHALL BE PROVIDED IN ACCORDANCE WITH THE APPROVED NPDES GENERAL PERMIT.
9. NOTIFY NEW JERSEY ONE CALL (800 272–1000 OR 811) NOT LESS THAN THREE BUSINESS DAYS AND NOT MORE THAN 10 BUSINESS DAYS PRIOR TO THE BEGINNING OF THE EXCAVATION OR DEMOLITION. NEW JERSEY ONE CALL IS NOT EXPECTED TO HAVE COMPLETE RECORD OF UTILITIES FOR THE SITE. VERIFY AND MARK UTILITY AND APPURTENANCE LOCATIONS WITHIN THE PROJECT LIMITS PRIOR TO WORK ON–SITE.
10. STAKE THE LOCATION OF EXCAVATION AND DISTURBED AREAS PRIOR TO ACTUAL WORK.
11. ALL VEHICLES EXITING THE SITE SHALL TRAVEL OVER THE STABILIZED CONSTRUCTION ACCESS CONSTRUCTED, MAINTAINED AND INSPECTED IN ACCORDANCE WITH THE APPROVED NPDES GENERAL PERMIT. PROVIDE INGRESS/EGRESS CONTROL INTO THE SITE AS PART OF MOBILIZATION ACTIVITIES.
12. PROVIDE PROTECTION FOR EXISTING UTILITIES TO REMAIN IN SERVICE. PROVIDE TEMPORARY SERVICES REQUIRED TO PERFORM WORK.
13. PHASE CLEARING, DISTURBANCE, AND BORROW OPERATIONS TO MINIMIZE EROSION POTENTIAL.
14. MAINTAIN POSITIVE DRAINAGE AT ALL TIMES DURING AND AFTER CONSTRUCTION.

ABBREVIATIONS:

&	AND
@	AT
CL	CENTER LINE
°	DEGREES
'	FOOT, FEET
>	GREATER THAN
<	LESS THAN
"	INCH, INCHES
#	NUMBER, POUND
%	PERCENT
+	PLUS
+/–	PLUS OR MINUS
K20	POTASH EQUIVALENT
P205	PHOSPHATE EQUIVALENT
AC	ACRE
AGIP	AT–GRADE INLET PROTECTION
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE
AOC	AREA OF CONCERN
APPROX	APPROXIMATE
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS INTERNATIONAL
AASHTO	AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS
AWG	AMERICAN WIRE GAUGE
BGS	BELOW GROUND SURFACE
BMP	BEST MANAGEMENT PRACTICE
BOT	BOTTOM
C TO C	CENTER TO CENTER
CD	CHECK DAM
CEA	CLASSIFICATION EXCEPTION AREA
CFR	CODE OF FEDERAL REGULATIONS
CFS	CUBIC FEET PER SECOND
CI	CONTOUR INTERVAL (WHEN USED FOR GRADING)
CI	CAST IRON (WHEN USED FOR MATERIAL TYPE)
CIP	CAST–IN–PLACE (WHEN USED WITH CONCRETE)
CIP	CAST IRON PIPE
CLSM	CONTROLLED LOW STRENGTH MATERIAL
CM/SEC	CENTIMETERS PER SECOND
CO	CLEAN–OUT
CPP	CORRUGATED POLYETHYLENE PIPE
CY	CUBIC YARD
DET	DETAIL
DI	DUCTILE IRON
DIA	DIAMETER
DIPS	DUCTILE IRON PIPE SIZE
E	EASTING
E&SC	EROSION AND SEDIMENT CONTROL PLAN
ECB	EROSION CONTROL BLANKET
EL, ELEV	ELEVATION
ELB	ELBOW
ELEC	ELECTRIC
EPD	METHYLENE PROPYLENE DIENEPOLYMER
EW	EACH WAY
EXIST	EXISTING
EXP	EXPANSION
FEMA	FEDERAL EMERGENCY MANAGEMENT AGENCY
FPP–R	FLEXIBLE POLYPROPYLENE–REINFORCED
FL	FILTER LOG
FPS	FEET PER SECOND
FSCD	FREEHOLD SOIL CONSERVATION DISTRICT
FT	FOOT, FEET

ABBREVIATIONS: CONT

FTG	FOOTING
GA	GAGE
GCL	GEOSYNTHETIC CLAY LINER
GDL	GEOCOMPOSITE DRAINAGE LAYER
GRI	GEOSYNTHETIC RESEARCH INSTITUTE
HDPE	HIGH DENSITY POLYETHYLENE
ID	IDENTIFICATION
ID	INSIDE DIAMETER (WHEN USED WITH CIRCULAR FEATURES)
IN	INCH, INCHES
INV	INVERT
IPS	IRON PIPE SIZE
K	POTASSIUM
LB/FT	POUNDS PER FOOT
LB, LBS	POUND, POUNDS
LF	LINEAR FEET (FOOT)
LLDPE	LINEAR LOW DENSITY POLYETHYLENE
LG	LONG
LOD	LIMIT OF DISTURBANCE
MAX	MAXIMUM
mg/kg	MILLIGRAM PER KILOGRAM
MH	MANHOLE
MHHW	MEAN HIGHER HIGH WATER
MHW	MEAN HIGH WATER
MIN	MINIMUM
MLW	MEAN LOW WATER
MLLW	MEAN LOWER LOW WATER
mm	MILLIMETER
MSF	ONE THOUSAND SQUARE FEET
MSL	MEAN SEA LEVEL
N	NORTHING (WHEN USED FOR GRID COORDINATE SYSTEM)
N	NITROGEN (WHEN USED FOR SEEDING MIXTURE TABLES)
NA	NOT APPLICABLE
NAD	NORTH AMERICAN DATUM
NJAC	NEW JERSEY ADMINISTRATIVE CODE
NAVD	NORTH AMERICAN VERTICAL DATUM
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NJDEP	NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
NJDNR	NEW JERSEY DEPARTMENT OF NATURAL RESOURCES
NJDOT	NEW JERSEY DEPARTMENT OF TRANSPORTATION
NJMUTCD	NEW JERSEY MANUAL OF UNIFORM TRAFFIC CONTROL DEVICES
NJSA	NEW JERSEY STATUTES ANNOTATED
NJUPS	NEW JERSEY UTILITIES PROTECTION SERVICE
NLF	NORTH LANDFARM
NOI	NOTICE OF INTENT
NOT	NOTICE OF TERMINATION
NPDES	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
NSA	NATIONAL STONE ASSOCIATION
NTS	NOT TO SCALE
NW	NONWOVEN
NW–P	NONWOVEN NEEDLE PUNCHED
OC	ON CENTER
OD	OUTSIDE DIAMETER
OHWM	ORDINARY HIGH WATER MARK
OZ/SY	OUNCES PER SQUARE YARD
P	PHOSPHOROUS
PCF	POUNDS PER CUBIC FOOT
PE	POLYETHYLENE
PERF	PERFORATED
PLS	PURE LIVE SEED
PSF	POUNDS PER SQUARE FOOT
PSI	POUNDS PER SQUARE INCH
PST	PORTABLE SEDIMENT TANK
PVC	POLYVINYL CHLORIDE
Q	FLOW
QA	QUALITY ASSURANCE
QC	QUALITY CONTROL
RCP	REINFORCED CONCRETE PIPE
RO	ROUGH OPENING
RQD	ROCK QUALITY DESIGNATION
RECP	ROLLED EROSION CONTROL PRODUCT
REV	REVISION
REQD	REQUIRED
RFA	REQUEST FOR AUTHORIZATION
SCA	STABILIZED CONSTRUCTION ACCESS
SCH	SCHEDULE
SDR	STANDARD DIMENSION RATIO
SEC	SECOND
SECT	SECTION
SESC	SOIL EROSION AND SEDIMENT CONTROL
SF	SILT FENCE (WHEN USED ON E&SC DRAWINGS)
SF	SQUARE FOOT (WHEN USED TO INDICATE SURFACE AREA)
SPCS	STATE PLANE COORDINATE SYSTEMS
PP	SPECIES
SQ FT	SQUARE FEET
SS	STAINLESS STEEL
SSF	SUPER SILT FENCE
ST	SEDIMENT TRAP
STL	STEEL
SWPPP	STORMWATER POLLUTION PREVENTION PLAN
SY	SQUARE YARD
T&B	TOP AND BOTTOM
TRM	TURF REINFORCEMENT MAT
TSF	TONS PER SQUARE FOOT
TSOS	TEMPORARY STONE OUTLET PROTECTION
TWA	TREATMENT WORKS APPROVAL
TYP	TYPICAL
USCS	UNIFIED SOIL CLASSIFICATION SYSTEM
UON	UNLESS OTHERWISE NOTED
US	UNITED STATES
USEPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
UV	ULTRAVIOLET
VERT	VERTICAL
W	WIDTH
WSE	WATER SURFACE ELEVATION
W/	WITH
W/O	WITHOUT
WO	WHERE OCCURS
WT	WEIGHT
YR	YEAR

ABBREVIATIONS AND SYMBOLS INDICATED ON THIS SHEET ARE FOR REFERENCE ONLY AND DO NOT INDICATE THEIR INCORPORATION IN THE DESIGN.

GENERAL LEGEND:

- EXISTING ELEVATION CONTOUR (1 FT CI)
- AOC LIMITS (APPROX)
- EXISTING CHAIN LINK FENCE
- EXISTING RAILROAD
- EXISTING EDGE OF PAVEMENT
- EXISTING EDGE OF GRAVEL
- EXISTING EDGE OF WATER
- EXISTING UNDERGROUND ELECTRIC LINE
- EXISTING STORMWATER LINE
- EXISTING LEACHATE COLLECTION SYSTEM
- EXISTING SANITARY SEWER LINE
- EXISTING TOE OF SLOPE – NLF
- EXISTING TOE OF SLOPE
- EXISTING TOP OF BANK
- EXISTING UTILITY POLE WITH LIGHT POST
- EXISTING UTILITY POLE
- EXISTING FIRE HYDRANT
- EXISTING MANHOLE
- EXISTING INLET
- EXISTING HEADWALL/ENDWALL
- EXISTING WATER VALVE
- EXISTING BOLLARD
- EXISTING STANDING WATER
- EXISTING DIKE
- EXISTING MONITORING WELL (LN–6)
- EXISTING LYSIMETER (LY–7)
- PROPOSED ELEVATION CONTOUR (1 FT CI)
- PROPOSED SPOT ELEVATIONS (EL 19.7)
- PROPOSED SLOPE AND DIRECTION (5.0%)
- PROPOSED STATION (1+00)
- PROPOSED SILT FENCE
- PROPOSED LIMIT OF DISTURBANCE
- PROPOSED PASSIVE GAS VENT
- PROPOSED BREAK IN GRADE (FINAL SURFACE)
- PROPOSED BREAK IN GRADE (SUBGRADE SURFACE)
- PROPOSED LIMIT OF FINAL GRADING
- PROPOSED LIMIT OF SUBGRADE REGRADING

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY · ALAN E. BRIGGS · No. GE38785 · PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: SCC	DATE: 08/14/19	KEY ENVIRONMENTAL INCORPORATED	
CHKD: LZ	DATE: 08/23/19		
APPD: AEB	DATE: 08/23/19		
SCALE:	AS SHOWN		

SOIL REMEDIAL ACTION DESIGN
AOC–1: NORTH LANDFARM
HESS CORPORATION–FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

GENERAL NOTES AND LEGEND

PROJECT NO: 19–819

NLF–G–002

y:\00civil\earth systems\port reading–north landfarm\production drawings\3_soil remedial action design\nlf–g–002 – gen notes & legend.dwg Last Saved By: Emaloney 10/16/2019 8:54 AM Plotted By: Elizabeth Maloney 10/16/2019 8:55 AM Scale: 1:1

FREEHOLD SOIL CONSERVATION DISTRICT SOIL EROSION AND SEDIMENT CONTROL NOTES

1. THE FREEHOLD SOIL CONSERVATION DISTRICT SHALL BE NOTIFIED FORTY–EIGHT (48) HOURS IN ADVANCE OF ANY SOIL DISTURBING ACTIVITY.
2. ALL SOIL EROSION AND SEDIMENT CONTROL PRACTICES ARE TO BE INSTALLED PRIOR TO SOIL DISTURBANCE, OR IN THEIR PROPER SEQUENCE, AND MAINTAINED UNTIL PERMANENT PROTECTION IS ESTABLISHED.
3. ANY CHANGES TO THE CERTIFIED SOIL EROSION AND SEDIMENT CONTROL PLANS WILL REQUIRE THE SUBMISSION OF REVISED SOIL EROSION AND SEDIMENT CONTROL PLANS TO THE DISTRICT FOR RE–CERTIFICATION. THE REVISED PLANS MUST MEET ALL CURRENT STATE SOIL EROSION AND SEDIMENT CONTROL STANDARDS.
4. N.J.S.A 4:24–39 ET. SEQ. REQUIRES THAT NO CERTIFICATES OF OCCUPANCY BE ISSUED BEFORE THE DISTRICT DETERMINES THAT A PROJECT OR PORTION THEREOF IS IN FULL COMPLIANCE WITH THE CERTIFIED PLAN AND STANDARDS FOR SOIL EROSION AND SEDIMENT CONTROL IN NEW JERSEY AND A REPORT OF COMPLIANCE HAS BEEN ISSUED. UPON WRITTEN REQUEST FROM THE APPLICANT, THE DISTRICT MAY ISSUE A REPORT OF COMPLIANCE WITH CONDITIONS ON A LOT–BY–LOT OR SECTION–BY–SECTION BASIS, PROVIDED THAT THE PROJECT OR PORTION THEREOF IS IN SATISFACTORY COMPLIANCE WITH THE SEQUENCE OF DEVELOPMENT AND TEMPORARY MEASURES FOR SOIL EROSION AND SEDIMENT CONTROL HAVE BEEN IMPLEMENTED, INCLUDING PROVISIONS FOR STABILIZATION AND SITE WORK.
5. ANY DISTURBED AREAS THAT WILL BE LEFT EXPOSED MORE THAN SIXTY (60) DAYS, AND NOT SUBJECT TO CONSTRUCTION TRAFFIC, WILL IMMEDIATELY RECEIVE A TEMPORARY SEEDING. IF THE SEASON PREVENTS THE ESTABLISHMENT OF TEMPORARY COVER, THE DISTURBED AREAS WILL BE MULCHED WITH STRAW, OR EQUIVALENT MATERIAL, AT A RATE OF 2 TO 2 ½ TONS PER ACRE, ACCORDING TO THE STANDARD FOR STABILIZATION WITH MULCH ONLY.
6. IMMEDIATELY FOLLOWING INITIAL DISTURBANCE OR ROUGH GRADING, ALL CRITICAL AREAS SUBJECT TO EROSION (I.E. SOIL STOCKPILES, STEEP SLOPES AND ROADWAY EMBANKMENTS) WILL RECEIVE TEMPORARY SEEDING IN COMBINATION WITH STRAW MULCH OR A SUITABLE EQUIVALENT, AND A MULCH ANCHOR, IN ACCORDANCE WITH STATE STANDARDS.
7. A SUB–BASE COURSE WILL BE APPLIED IMMEDIATELY FOLLOWING ROUGH GRADING AND INSTALLATION OF IMPROVEMENTS TO STABILIZE STREETS, ROADS, DRIVEWAYS, AND PARKING AREAS. IN AREAS WHERE NO UTILITIES ARE PRESENT, THE SUB–BASE SHALL BE INSTALLED WITHIN FIFTEEN (15) DAYS OF THE PRELIMINARY GRADING.
8. THE STANDARD FOR STABILIZED CONSTRUCTION ACCESS REQUIRES THE INSTALLATION OF A PAD OF CLEAN CRUSHED STONE AT POINTS WHERE TRAFFIC WILL BE ACCESSING THE CONSTRUCTION SITE. AFTER INTERIOR ROADWAYS ARE PAVED, INDIVIDUAL LOTS REQUIRE A STABILIZED CONSTRUCTION ACCESS CONSISTING OF ONE INCH TO TWO INCH (1"–2") STONE FOR A MINIMUM LENGTH OF TEN FEET (10') EQUAL TO THE LOT ENTRANCE WIDTH. ALL OTHER ACCESS POINTS SHALL BE BLOCKED OFF.
9. ALL SOIL WASHED, DROPPED, SPILLED, OR TRACKED OUTSIDE THE LIMIT OF DISTURBANCE OR ONTO PUBLIC RIGHT–OF–WAYS WILL BE REMOVED IMMEDIATELY.
10. PERMANENT VEGETATION IS TO BE SEEDED OR SODDED ON ALL EXPOSED AREAS WITHIN TEN (10) DAYS AFTER FINAL GRADING.
11. AT THE TIME THAT SITE PREPARATION FOR PERMANENT VEGETATIVE STABILIZATION IS GOING TO BE ACCOMPLISHED, ANY SOIL THAT WILL NOT PROVIDE A SUITABLE ENVIRONMENT TO SUPPORT ADEQUATE VEGETATIVE GROUND COVER SHALL BE REMOVED OR TREATED IN SUCH A WAY THAT IT WILL PERMANENTLY ADJUST THE SOIL CONDITIONS AND RENDER IT SUITABLE FOR VEGETATIVE GROUND COVER. IF THE REMOVAL OR TREATMENT OF THE SOIL WILL NOT PROVIDE SUITABLE CONDITIONS, NON–VEGETATIVE MEANS OF PERMANENT GROUND STABILIZATION WILL HAVE TO BE EMPLOYED.
12. IN ACCORDANCE WITH THE STANDARD FOR MANAGEMENT OF HIGH ACID PRODUCING SOILS, ANY SOIL HAVING A pH OF 4 OR LESS OR CONTAINING IRON SULFIDES SHALL BE ULTIMATELY PLACED OR BURIED WITH LIMESTONE APPLIED AT THE RATE OF 10 TONS/ACRE, (OR 450 LBS/1,000 SQ FT OF SURFACE AREA) AND COVERED WITH A MINIMUM OF 12" OF SETTLED SOIL WITH A pH OF 5 OR MORE, OR 24" WHERE TREES OR SHRUBS ARE TO BE PLANTED.
13. CONDUIT OUTLET PROTECTION MUST BE INSTALLED AT ALL REQUIRED OUTFALLS PRIOR TO THE DRAINAGE SYSTEM BECOMING OPERATIONAL.
14. UNFILTERED DEWATERING IS NOT PERMITTED. NECESSARY PRECAUTIONS MUST BE TAKEN DURING ALL DEWATERING OPERATIONS TO MINIMIZE SEDIMENT TRANSFER. ANY DEWATERING METHODS USED MUST BE IN ACCORDANCE WITH THE STANDARD FOR DEWATERING.
15. SHOULD THE CONTROL OF DUST AT THE SITE BE NECESSARY, THE SITE WILL BE SPRINKLED UNTIL THE SURFACE IS WET, TEMPORARY VEGETATIVE COVER SHALL BE ESTABLISHED OR MULCH SHALL BE APPLIED AS REQUIRED BY THE STANDARD FOR DUST CONTROL.
16. STOCKPILE AND STAGING LOCATIONS ESTABLISHED IN THE FIELD SHALL BE PLACED WITHIN THE LIMIT OF DISTURBANCE ACCORDING TO THE CERTIFIED PLAN. STAGING AND STOCKPILES NOT LOCATED WITHIN THE LIMIT OF DISTURBANCE WILL REQUIRE CERTIFICATION OF A REVISED SOIL EROSION AND SEDIMENT CONTROL PLAN. CERTIFICATION OF A NEW SOIL EROSION AND SEDIMENT CONTROL PLAN MAY BE REQUIRED FOR THESE ACTIVITIES IF AN AREA GREATER THAN 5,000 SQUARE FEET IS DISTURBED.
17. ALL SOIL STOCKPILES ARE TO BE TEMPORARILY STABILIZED IN ACCORDANCE WITH SOIL EROSION AND SEDIMENT CONTROL NOTE #6.
18. THE PROPERTY OWNER SHALL BE RESPONSIBLE FOR ANY EROSION OR SEDIMENTATION THAT MAY OCCUR BELOW STORMWATER OUTFALLS OR OFFSITE AS A RESULT OF CONSTRUCTION OF THE PROJECT.

NOTE

SOIL EROSION AND SEDIMENT CONTROL NOTES INDICATED OBTAINED FROM FREEHOLD SOIL CONSERVATION DISTRICT (MARCH 2014). SESC NOTES ARE STANDARD AND ARE THEREFORE NOT AMENDED.

SEQUENCE OF CONSTRUCTION

THE MAJOR CONSTRUCTION ACTIVITIES ASSOCIATED WITH CLOSURE OF NORTH LANDFARM (NLF) AND THEIR SEQUENCE ARE PRESENTED TO PROVIDE A GENERAL UNDERSTANDING OF CLOSURE ACTIVITY IMPLEMENTATION. THE SEQUENCE OF CONSTRUCTION IS PROVIDED FOR ILLUSTRATIVE PURPOSES AND MAY BE MODIFIED BY THE CONTRACTOR PROVIDED THAT ALL PERMIT CONDITIONS, DESIGN CRITERIA, AND SOIL EROSION, SEDIMENT, AND STORMWATER MANAGEMENT PRACTICES ARE MET. PROPOSED MODIFICATIONS MAY REQUIRE SUBMITTAL TO THE STAKEHOLDER(S) HAVING APPROVAL AUTHORITY. ANY MODIFICATIONS TO THIS SEQUENCE OF CONSTRUCTION SHALL BE SUBMITTED TO ENGINEER FOR REVIEW TO ASCERTAIN IF THE PROJECT REQUIREMENTS WILL BE MET.

1. NOTIFY THE NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION AND FREEHOLD SOIL CONSERVATION DISTRICT AT LEAST 7 DAYS PRIOR TO IMPLEMENTING CONSTRUCTION ACTIVITIES. HOLD PRE–CONSTRUCTION MEETING WITH ENGINEER AND THE NJDEP INSPECTOR.
2. INSPECT SITE PRIOR TO CONSTRUCTION TO VERIFY EXISTING SITE CONDITIONS AND UNDERGROUND UTILITY LOCATIONS.
3. ESTABLISH HORIZONTAL AND VERTICAL CONTROL FOR EXCAVATION AND LIMIT OF DISTURBANCE. STAKE THE LOCATIONS OF AREAS TO BE DISTURBED OR EXCAVATED PRIOR TO ACTUAL WORK.
4. INSTALL PERIMETER CONTROLS FOR STABILIZED CONSTRUCTION ACCESS. INSTALL STABILIZED CONSTRUCTION ACCESS.
5. INSTALL REMAINING PERIMETER CONTROLS (E.G. SILT FENCE) PRIOR TO DISTURBING UPGRADIENT AREAS.
6. INSTALL DECONTAMINATION PAD.
7. CLEAR AND GRUB VEGETATIVE MATTER AND MANAGE WITHIN NLF LIMITS.
8. REMOVE STANDING WATER FROM WITHIN NLF LIMITS AND MANAGE REMOVED WATER. LOWER THE LIQUID LEVEL TO A MINIMUM OF 1 FOOT BELOW THE WORK SURFACE AND MANAGE REMOVED WATER. LIQUID LEVEL ELEVATION MAY BE LOWERED BY PROVIDING TEMPORARY SUMPS LOCATED WITHIN NLF LIMITS.
9. INSTALL AND MAINTAIN THROUGHOUT CONSTRUCTION RUN–OFF CONTROL FEATURES TO CONTAIN RUN–OFF TO WITHIN THE LIMITS OF NLF.
10. PROOF–ROLL SURFACES TO RECEIVE REGRADED NLF MATERIAL, REGRADED NLF SOUTHEAST OR SOUTHWEST DIKE MATERIAL, AOC–1 RELATED MATERIAL OR COMMON FILL. PLACE, COMPACT, AND TEST MATERIALS AS INDICATED. GRADE SELECT NLF MATERIAL, REGRADED NLF SOUTHEAST OR SOUTHWEST DIKE MATERIAL, AOC–1 RELATED MATERIAL OR COMMON FILL WITHIN NLF LIMITS TO INDICATED SUBGRADE ELEVATIONS.
11. INSTALL PASSIVE GAS VENTS.
12. INSTALL GEOSYNTHETIC MATERIAL PORTIONS OF COARSE AGGREGATE SURFACED CAP.
13. INSTALL PROTECTION LAYER AND SURFACE PORTIONS OF COARSE AGGREGATE SURFACED CAP.
14. INSTALL CHAIN LINK SECURITY FENCE AND GATE.
15. REMOVE ASSOCIATED TEMPORARY EROSION, SEDIMENT AND STORMWATER MANAGEMENT PRACTICES DOWNGRADIENT OF THE "FINAL STABILIZATION" AREA UPON ACHIEVING AND RECEIVING FROM THE ENGINEER AND FREEHOLD SCD INSPECTOR ACCEPTANCE OF "FINAL STABILIZATION".

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY · ALAN E. BRIGGS · No. GE38785 · PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: SCC	DATE: 08/14/19
CHKD: LZ	DATE: 08/23/19
APPD: AEB	DATE: 08/23/19
SCALE:	AS SHOWN

KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC–1: NORTH LANDFARM
HESS CORPORATION–FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

SOIL EROSION AND SEDIMENT CONTROL NOTES

PROJECT NO: 19–819

NLF–G–003

NORTH DRAINAGE DITCH

40" CIP
INV=1.0

N 630600

E 563900

6' CHAIN LINK FENCE

EDGE OF PAVEMENT

LN-2

LN-6

LN-3

CONC. RETAINING WALL

EDGE OF PAVEMENT

GRAVEL BERM

LY-7

OVERGROWN VEGETATION

TOP OF EXISTING AST 7945 SECONDARY CONTAINMENT DIKE

EDGE OF PAVEMENT

EDGE OF PAVEMENT

N 630400

LY-6

AOC - 1 :
NORTH LANDFARM
AREA

LN-7

CONC.

NORTH LANDFARM LIMITS
(TOE OF EXISTING DIKE)

DIKE

PEAK OF EXISTING NLF SOUTHWEST AND SOUTHEAST DIKE

ELEC. EQUIPMENT

7' CHAIN LINK FENCE

GRAVEL PAVED AREA

E 563500

E 563600

E 563700

E 563800

N 630300

N 630400

NOTES:
1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.

0 15 30 FEET

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
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24GA27961400

PLAN PREPARER:
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STATE OF NEW JERSEY · ALAN E. BRIGGS · No. GE38785 · PROFESSIONAL ENGINEER

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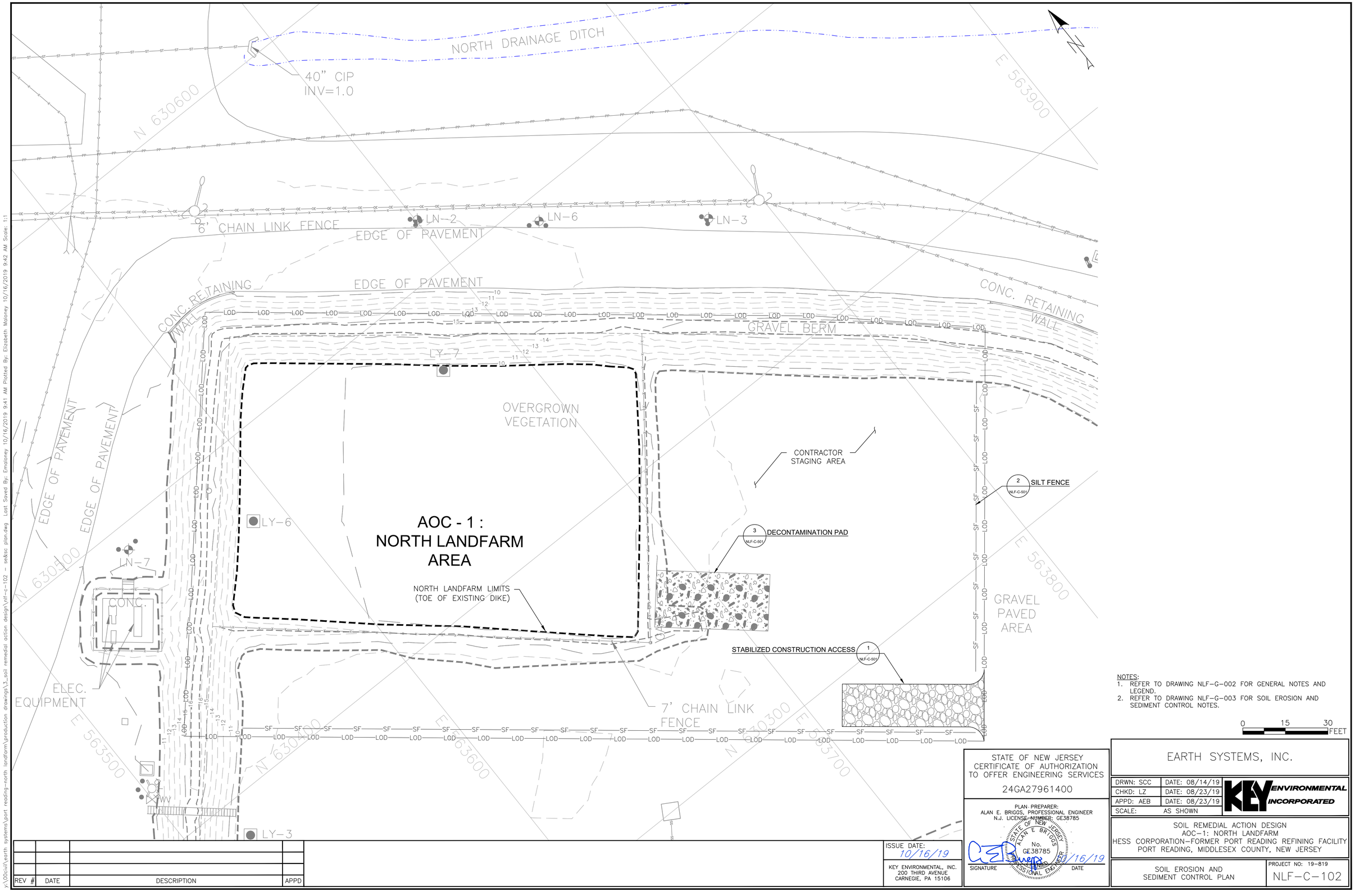
KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

EXISTING SITE CONDITIONS PLAN

PROJECT NO: 19-819

NLF-C-101



NOTES:
1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.
2. REFER TO DRAWING NLF-G-003 FOR SOIL EROSION AND SEDIMENT CONTROL NOTES.

0 15 30 FEET

REV #	DATE	DESCRIPTION	APPD

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KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
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24GA27961400

PLAN PREPARER:
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N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY
ALAN E. BRIGGS
No. GE38785
PROFESSIONAL ENGINEER

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EARTH SYSTEMS, INC.

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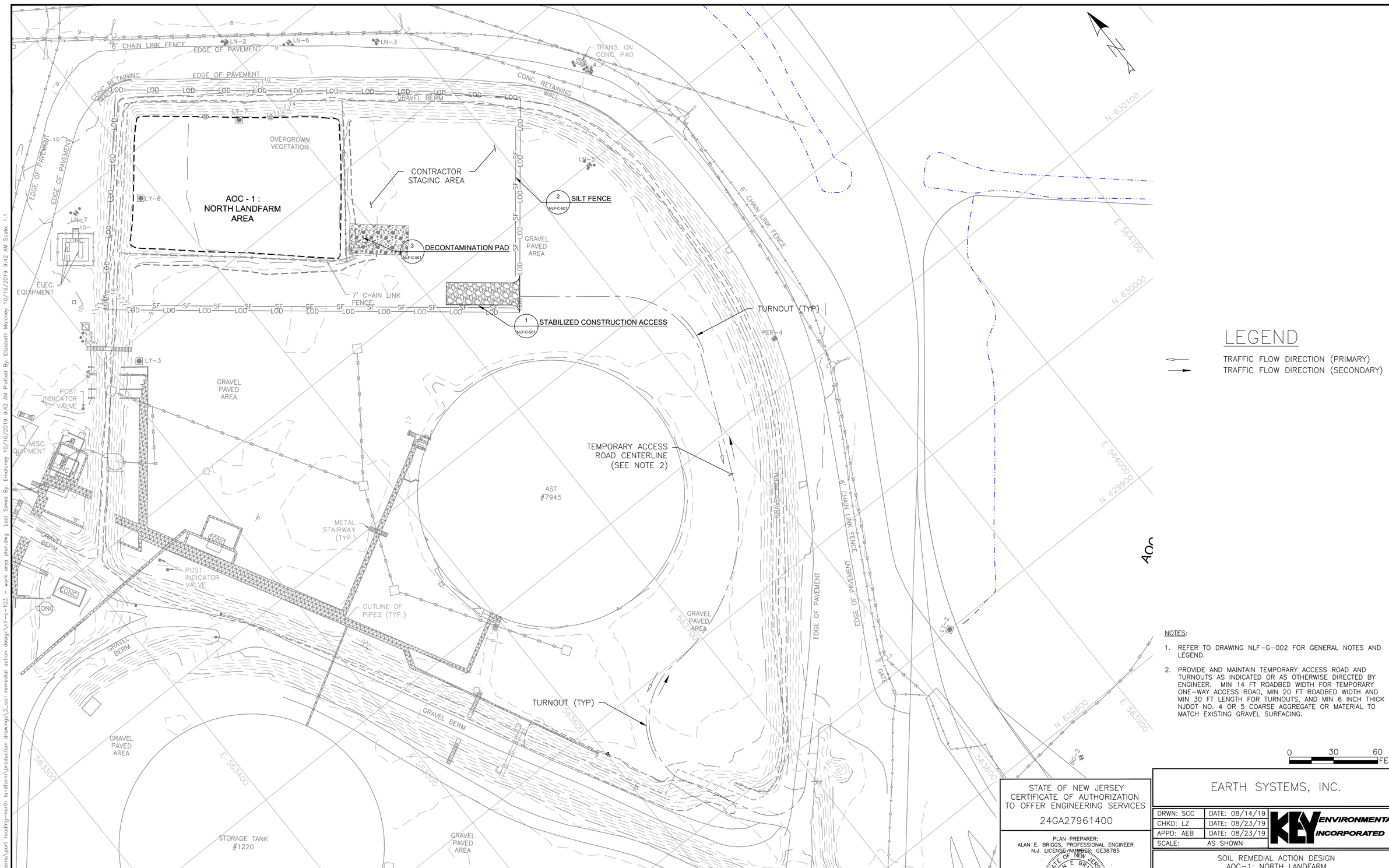
SCALE:	AS SHOWN	

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

SOIL EROSION AND SEDIMENT CONTROL PLAN

PROJECT NO: 19-819

NLF-C-102



LEGEND

TRAFFIC FLOW DIRECTION (PRIMARY)
TRAFFIC FLOW DIRECTION (SECONDARY)

NOTES:

1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.
2. PROVIDE AND MAINTAIN TEMPORARY ACCESS ROAD AND TURNOUTS AS INDICATED OR AS OTHERWISE DIRECTED BY ENGINEER. MIN 14 FT ROADBED WIDTH FOR TEMPORARY ONE-WAY ACCESS ROAD, MIN 20 FT ROADBED WIDTH AND MIN 30 FT LENGTH FOR TURNOUTS, AND MIN 6 INCH THICK NJDOT NO. 4 OR 5 COARSE AGGREGATE OR MATERIAL TO MATCH EXISTING GRAVEL SURFACING.

0 30 60 FEET

REV #	DATE	DESCRIPTION	APPD

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KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
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24GA27961400

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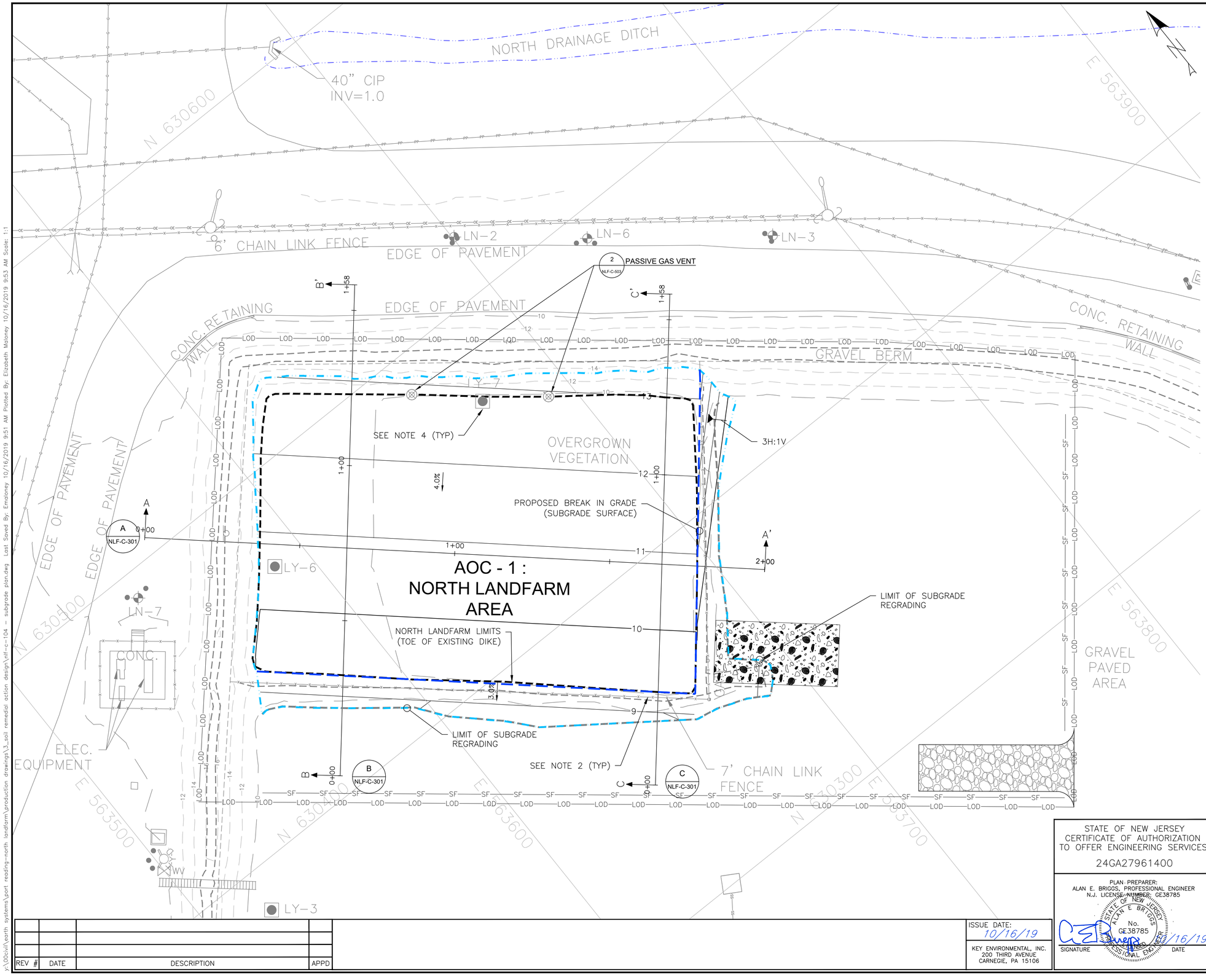
KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

WORK AREA PLAN

PROJECT NO: 19-819

NLF-C-103



NOTES:

1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.
2. REMOVE FABRIC, POSTS, AND ANCILLARY FENCE AND GATE COMPONENTS FROM SOUTHEAST AND SOUTHWEST NLF LIMITS AS INDICATED AND MANAGE AT AN APPROVED OFF-SITE RECYCLING OR DISPOSAL FACILITY. REMOVE, SIZE REDUCE, AND PLACE CONCRETE BASES BENEATH THE CAP SYSTEM PROVIDED A MINIMUM 12 INCHES OF COVER IS MAINTAINED BETWEEN CONCRETE BASES AND GEOSYNTHETIC CAP COMPONENTS; OTHERWISE REMOVE AND MANAGE CONCRETE BASES AT AN APPROVED OFF-SITE DISPOSAL FACILITY.
3. REMOVE GRUBBED MATERIAL (ROOTS, STICKS, AND SMALL STUMPS) AND SUBSEQUENTLY SIZE REDUCE (I.E., SHRED OR CHIP) FOR PLACEMENT IN A UNIFORM LAYER BENEATH THE CAP SYSTEM PROVIDED A MINIMUM 12 INCHES OF COVER IS MAINTAINED BETWEEN SIZE-REDUCED MATERIAL AND GEOSYNTHETIC CAP COMPONENTS; OTHERWISE DISPOSE AT AN APPROVED OFF-SITE DISPOSAL FACILITY.
4. ABANDON IN-PLACE 4 INCH DIAMETER PVC LYSIMETERS LY-6 AND LY-7 BY NEW JERSEY LICENSED WELL DRILLER VIA TREMIE GROUTING WITH PORTLAND CEMENT TYPE II FROM BOTTOM OF LYSIMETER TO WITHIN 1 FT OF EXISTING GROUND SUFACE. CUT LYSIMETER RISER 1 FT BELOW EXISTING GROUND SURFACE OR 1 FT BELOW PROPOSED LOWERMOST GEOSYNTHETIC CAP COMPONENT ELEVATION, WHICHEVER IS LOWER. DISPOSE LYSIMETER AND SURFACE FINISH MATERIAL WITHIN NLF LIMITS BENEATH THE CAP SYSTEM PROVIDED A MINIMUM 12 INCHES OF COVER IS MAINTAINED BETWEEN LYSIMETER MATERIALS AND GEOSYNTHETIC CAP COMPONENTS; OTHERWISE DISPOSE AT AN APPROVED OFF-SITE DISPOSAL FACILITY.
5. PROTECT EXISTING GROUNDWATER MONITORING WELLS TO REMAIN.
6. MAINTAIN ACCESS TO AST 7945 THROUGHOUT IMPLEMENTATION OF THE REMEDIAL ACTION, MAINTAIN THE FUNCTION AND OPERABILITY OF THE EXISTING AST 7945 SECONDARY CONTAINMENT SYSTEM CONSISTING OF, BUT NOT LIMITED TO, PERIMETER DIKE, PIPING, AND VALVES.

0 15 30 FEET

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY
ALAN E BRIGGS
No. GE38785
PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: SCC	DATE: 08/14/19	KEY ENVIRONMENTAL INCORPORATED
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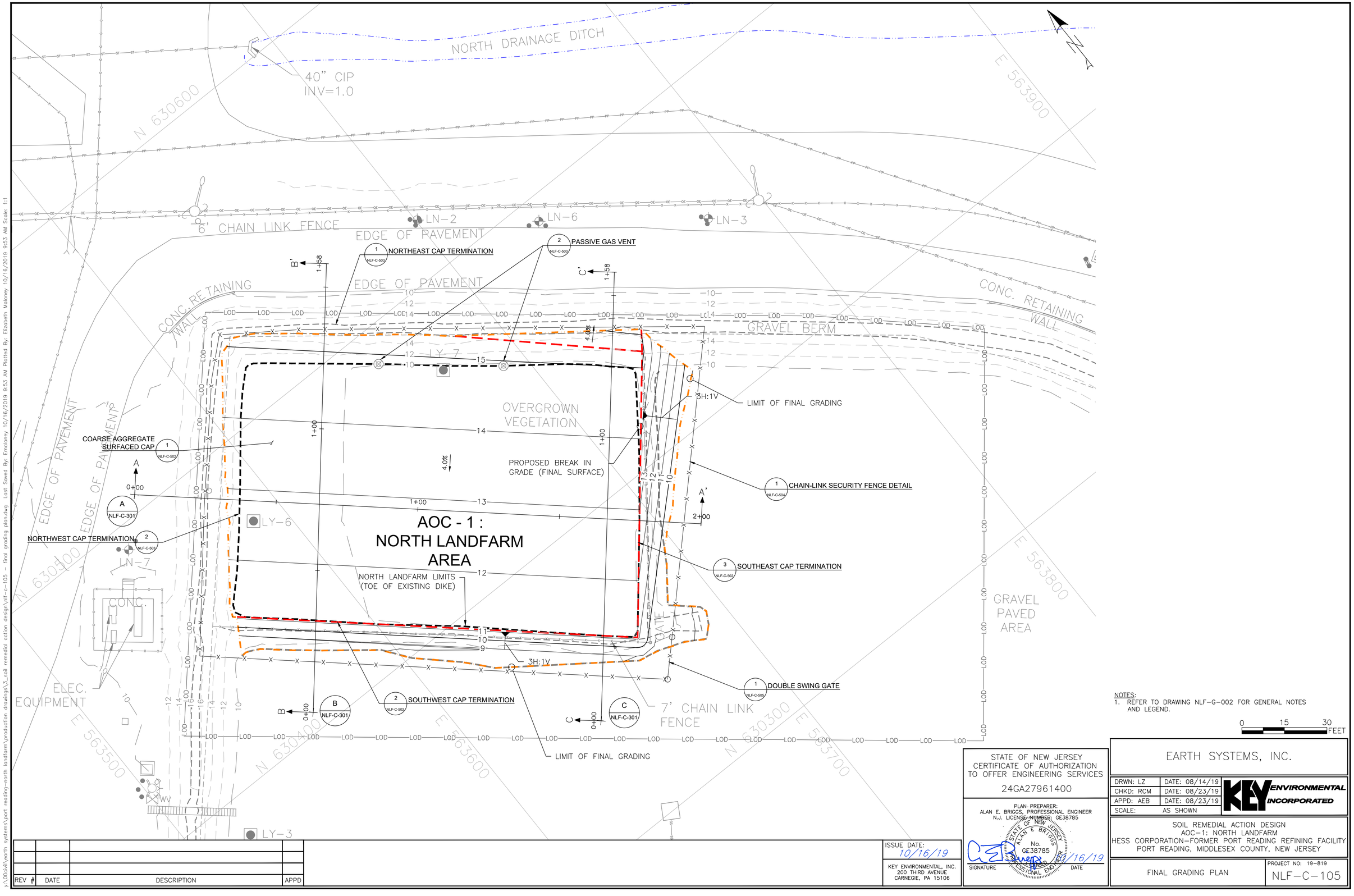
SCALE: AS SHOWN		

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

SUBGRADE GRADING PLAN

PROJECT NO: 19-819
NLF-C-104



NOTES:
1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.

REV #	DATE	DESCRIPTION	APPD

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PLAN PREPARER:
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N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY
ALAN E. BRIGGS
No. GE38785
PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: LZ	DATE: 08/14/19
CHKD: RCM	DATE: 08/23/19
APPD: AEB	DATE: 08/23/19
SCALE: AS SHOWN	

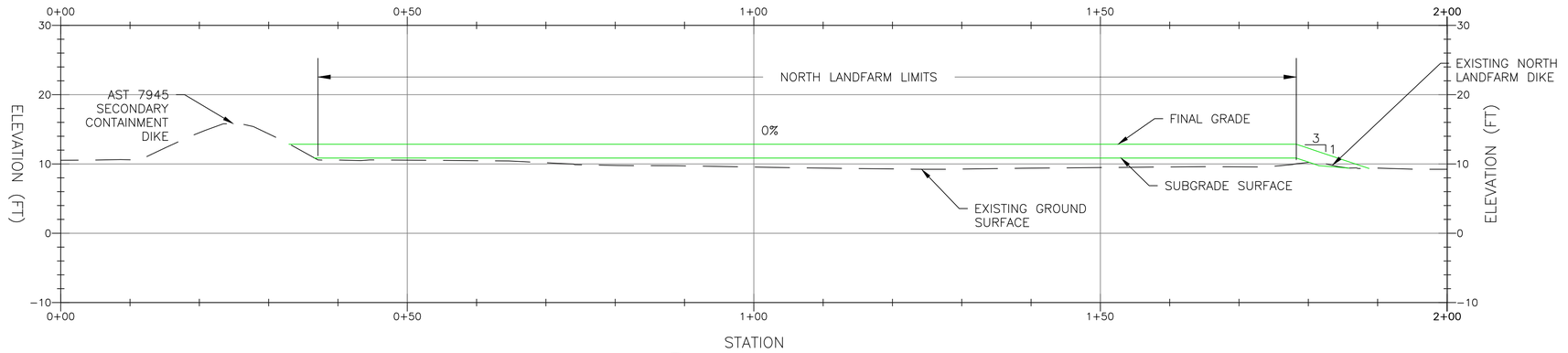
KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

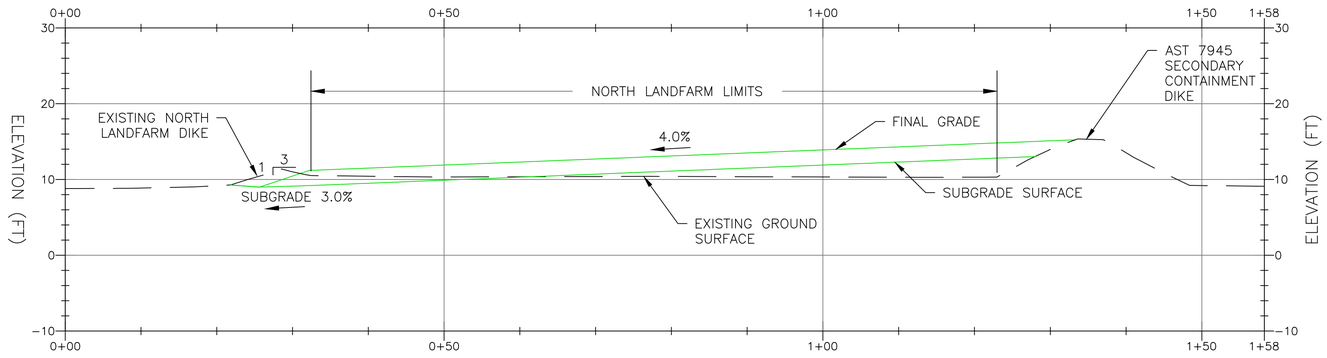
FINAL GRADING PLAN

PROJECT NO: 19-819

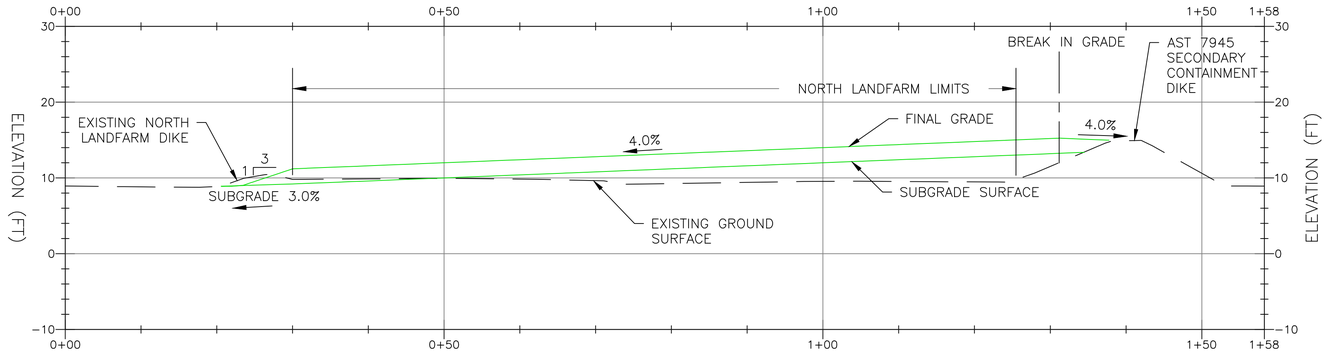
NLF-C-105



A
NLF-C-301
CROSS-SECTION A-A'



B
NLF-C-301
CROSS-SECTION B-B'



C
NLF-C-301
CROSS-SECTION C-C'

NOTES:
1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.

0 10 20
FEET

REV #	DATE	DESCRIPTION	APPD

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KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY
ALAN E. BRIGGS
No. GE38785
PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

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SCALE:	AS SHOWN

KEY ENVIRONMENTAL INCORPORATED

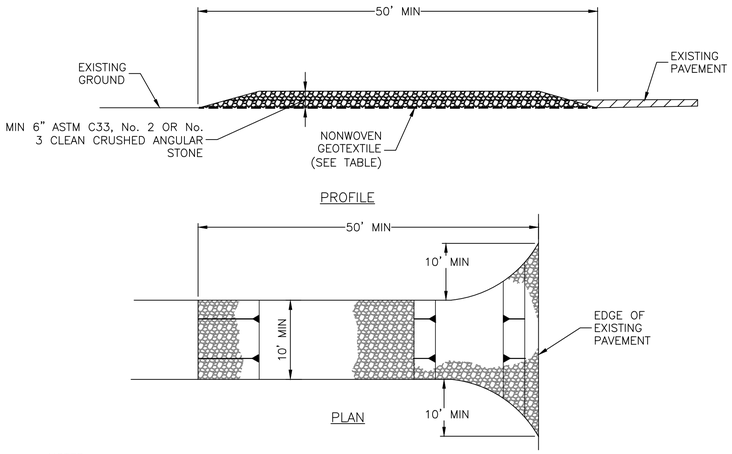
SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

CROSS SECTIONS

PROJECT NO: 19-819

NLF-C-301

y:\00civil\earth systems\port reading-north landfarm\production drawings\3_soil remedial action design\nlf-c-301 - cross sections.dwg Last Saved By: Emaloney 10/16/2019 8:59 AM Plotted By: Elizabeth Maloney 10/16/2019 9:00 AM Scale: 1:1



PROFILE

PLAN

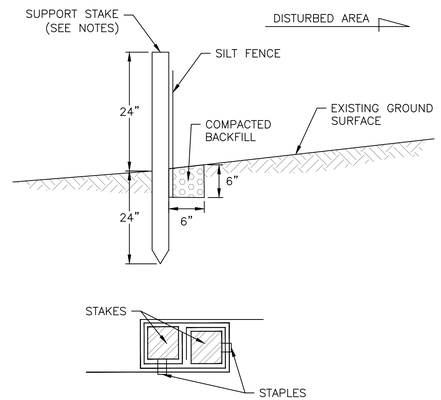
NOTES:

1. INSTALL STABILIZED CONSTRUCTION ACCESS AS SOON AS IS PRACTICABLE BEFORE MAJOR GRADING ACTIVITIES.
2. APPLY TOP DRESSING OF ADDITIONAL AGGREGATE AS CONDITIONS DEMAND. MUD SPILLED, DROPPED, WASHED OR TRACKED ONTO PUBLIC ROADS, OR ANY SURFACE WHERE RUNOFF IS NOT CHECKED BY SEDIMENT CONTROLS, SHALL BE REMOVED IMMEDIATELY. ACCOMPLISH REMOVAL BY SCRAPING OR SWEEPING.
3. ENTRANCE SHALL REMAIN IN PLACE UNTIL THE DISTURBED AREA IS STABILIZED OR REPLACED WITH A PERMANENT ROADWAY OR ENTRANCE.

NONWOVEN GEOTEXTILE PROPERTIES (1)		
PROPERTY	VALUE	ASTM TEST METHOD
GRAB TENSILE STRENGTH	248 LBS	D 4632
CBR PUNCTURE STRENGTH	500 LBS	D 6241
TRAPEZOIDAL TEAR STRENGTH	90 LBS	D 4533
PERMITTIVITY	0.02 SEC−1	D 4491
APPARENT OPENING SIZE	0.024 IN	D 4751
UV STABILITY	70% STRENGTH RETAINED @ 500 LIGHT HRS.	D 7238

(1) PROPERTIES CORRESPOND TO GRI−GT13(A) − ASTM VERSION, "TEST METHODS AND PROPERTIES FOR GEOTEXTILES USED AS SEPARATION BETWEEN SUBGRADE SOIL AND AGGREGATE", TABLE 1 (B) GEOTEXTILE PROPERTIES CLASS 2 (MODERATE SURVIVABILITY), ELONGATION <50%.

1 / NLF-C-501 STABILIZED CONSTRUCTION ACCESS
NTS

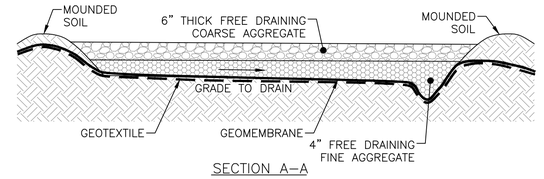


JOINING FENCE SECTIONS

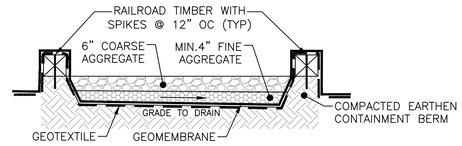
NOTES:

1. STAKES SPACED @ 8' MAXIMUM. USE 2" X 2" WOOD OR EQUIVALENT STEEL STAKES.
2. SILT FENCE MUST BE PLACED AT OR NEAR LEVEL EXISTING GRADE. BOTH ENDS OF THE BARRIER MUST BE EXTENDED AT LEAST 8 FEET UP SLOPE AT 45 DEGREES TO THE MAIN BARRIER ALIGNMENT.
3. SEDIMENT MUST BE REMOVED WHEN ACCUMULATIONS REACH 1/2 THE ABOVEGROUND HEIGHT OF THE FENCE.
4. ANY SECTION OF FILTER FABRIC FENCE WHICH HAS BEEN UNDERMINED OR TOPPED MUST BE IMMEDIATELY REPAIRED.
5. SILT FENCE FABRIC MUST INCORPORATE A DRAWSTRING IN THE TOP PORTION OF THE FENCE FOR ADDED STRENGTH.
6. EMBEDDED COIR FIBER LOGS OR STRAW BALE BARRIER MAY BE USED IN LIEU OF SILT FENCE SUBJECT TO ENGINEER APPROVAL.

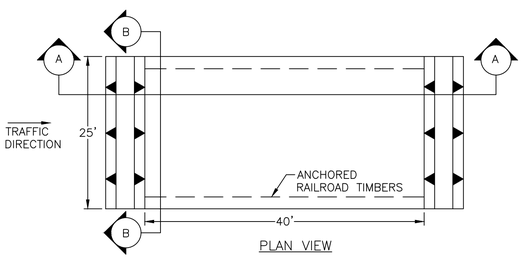
2 / NLF-C-501 SILT FENCE
NTS



SECTION A−A



SECTION B−B



PLAN VIEW

NOTES:

1. DECONTAMINATION PAD CONSTRUCTED WITHIN NLF LIMITS DIRECTLY ABOVE NLF MATERIAL MAY OMIT UNDERLYING GEOMEMBRANE AND GEOTEXTILE AND ALLOW WATER TO DRAIN FREELY. DECONTAMINATION PAD CONSTRUCTED OUTSIDE NLF LIMITS MUST INCLUDE GEOMEMBRANE AND GEOTEXILE TO PROVIDE CONTAINMENT.
2. PERIODIC INSPECTION AND NEEDED MAINTENANCE SHALL BE PROVIDED AFTER EACH RAIN EVENT.
3. DETAIL IS FOR ILLUSTRATIVE PURPOSES ONLY.

3 / NLF-C-501 DECONTAMINATION PAD
NTS

NOTES:
1. REFER TO DRAWING NLF−G−002 FOR GENERAL NOTES AND LEGEND.
2. REFER TO DRAWING NLF−G−003 FOR SOIL EROSION AND SEDIMENT CONTROL NOTES.

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY ALAN E. BRIGGS No. GE38785 PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: SCC	DATE: 08/14/18
CHKD: LZ	DATE: 08/23/19
APPD: AEB	DATE: 08/23/19
SCALE: AS SHOWN	

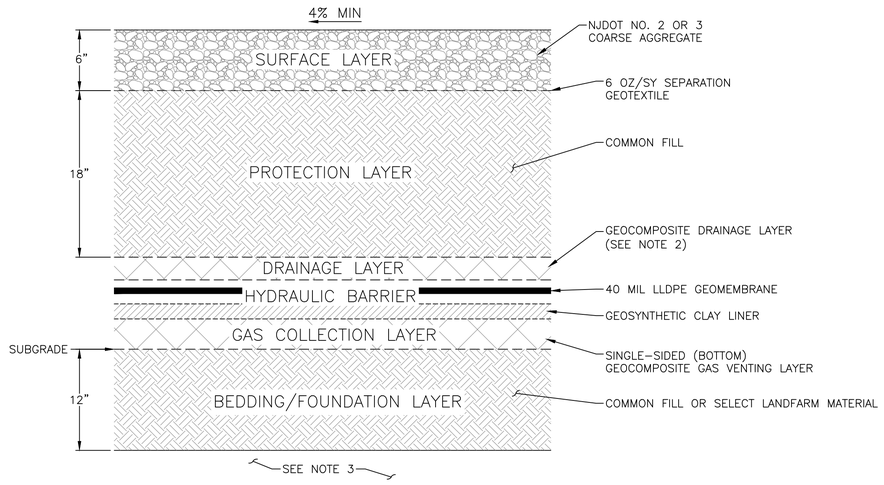
KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC−1: NORTH LANDFARM
HESS CORPORATION−FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

SOIL EROSION AND SEDIMENT CONTROL DETAILS

PROJECT NO: 19−819

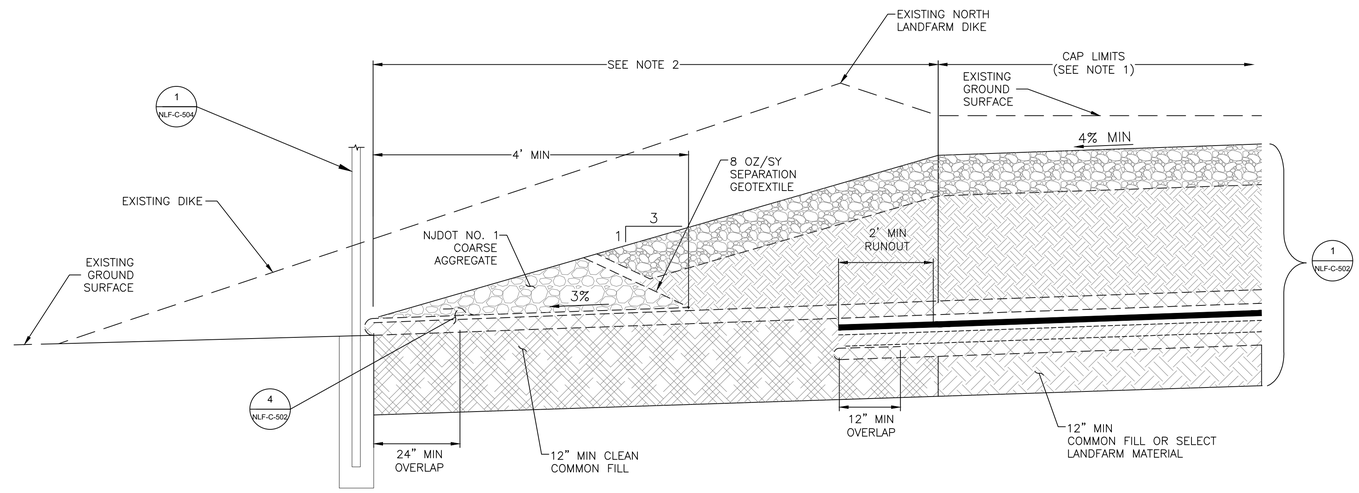
NLF−C−501



1 NLF-C-502 **COARSE AGGREGATE SURFACED CAP**
NTS

NOTES:

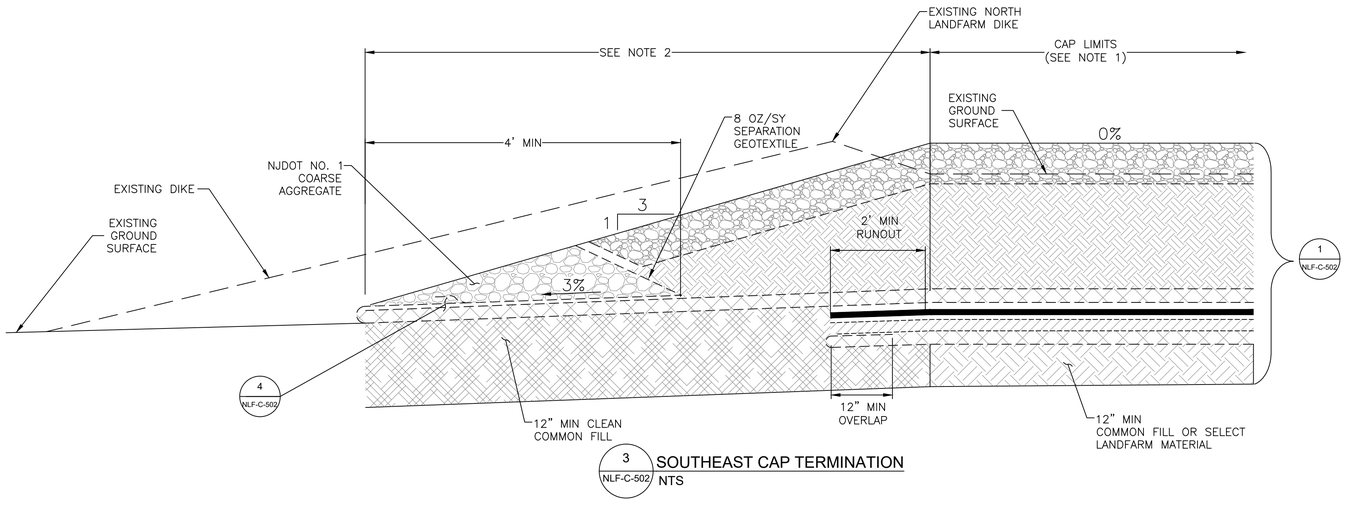
1. PROVIDE SMOOTH OR TEXTURED 40 MIL LLDPE GEOMEMBRANE.
2. PROVIDE DOUBLE-SIDED (SHOWN) OR SINGLE-SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.
3. LANDFARM MATERIAL, REGRADED LANDFARM MATERIAL, REGRADED LANDFARM SOUTHEAST OR SOUTHWEST DIKE MATERIAL OR AOC-1 RELATED MATERIAL.



2 NLF-C-502 **SOUTHWEST CAP TERMINATION**
NTS

NOTES:

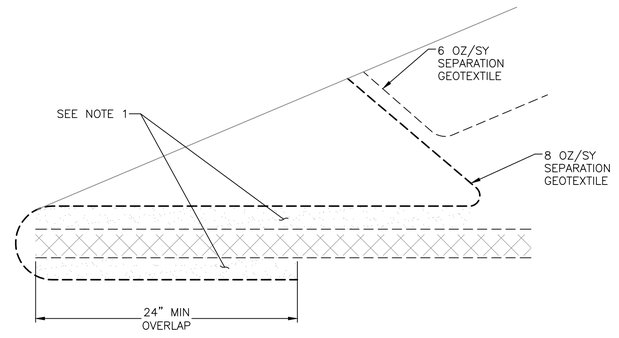
1. PROVIDE DOUBLE-SIDED (SHOWN) OR SINGLE-SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.
2. PROVIDE DOUBLE-SIDED GEOCOMPOSITE DRAINAGE LAYER (SHOWN) FROM CAP LIMITS TO CAP TERMINATION.
3. FENCE POST LOCATIONS SHOWN FOR SOUTHWEST CAP TERMINATION ARE TYPICAL FOR OTHER CAP TERMINATION DETAILS (NOT SHOWN). LOCATE FENCE AND GATE POSTS OUTSIDE OF AND ADJACENT TO, CAP TERMINATION. REFER TO DRAWING NLF-C-504 AND NLF-C-505 FOR FENCE DETAILS.



3 NLF-C-502 **SOUTHEAST CAP TERMINATION**
NTS

NOTES:

1. PROVIDE DOUBLE-SIDED (SHOWN) OR SINGLE-SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.
2. PROVIDE DOUBLE-SIDED GEOCOMPOSITE DRAINAGE LAYER (SHOWN) FROM CAP LIMITS TO CAP TERMINATION.



4 NLF-C-502 **OVERLAP DETAIL - A**
NTS

NOTES:

1. PROVIDE MIN 1 LB/SY CONCRETE SAND BETWEEN DOUBLE-SIDED GEOCOMPOSITE DRAINAGE LAYER AND SEPARATION GEOTEXTILE UNDERLYING NJDOT NO. 1 COARSE AGGREGATE.

NOTES:
1. REFER TO DRAWING NLF-G-002 FOR GENERAL NOTES AND LEGEND.

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24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY · ALAN E. BRIGGS · No. GE38785 · PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

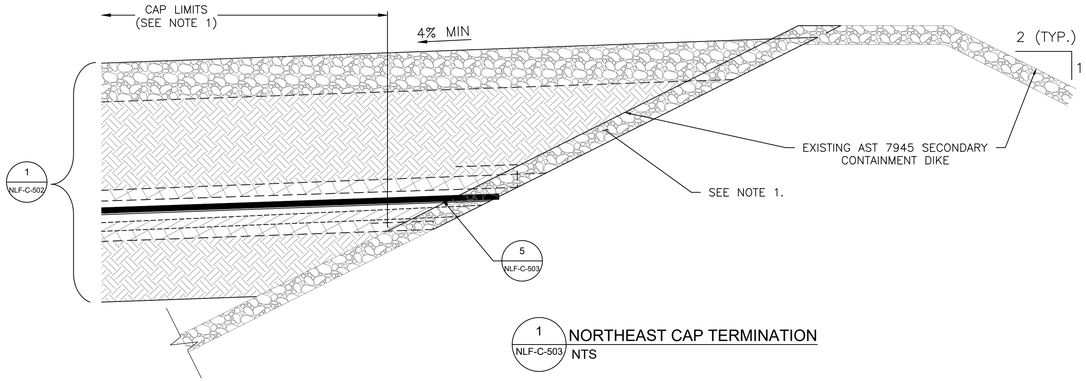
DRWN: LZ	DATE: 07/10/19
CHKD: RCM	DATE: 08/23/19
APPD: AEB	DATE: 08/23/19
SCALE:	AS SHOWN

KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

CAP DETAILS SHEET (1 OF 2)

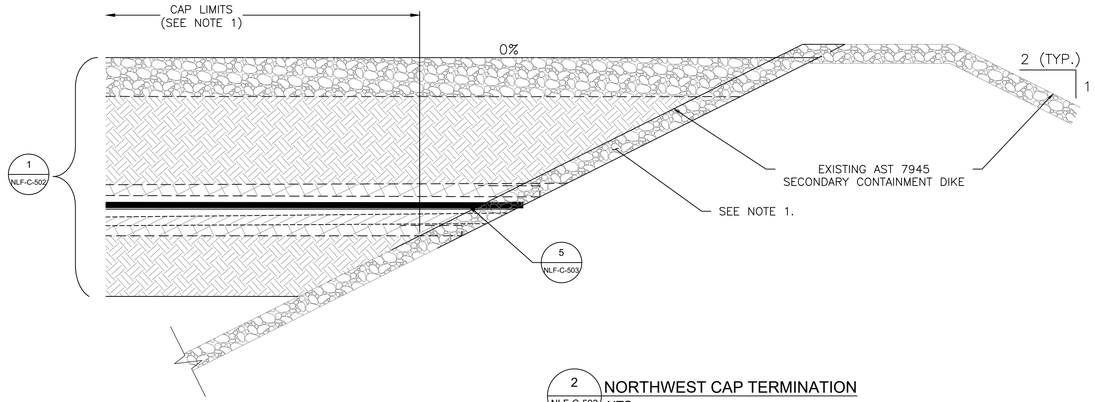
PROJECT NO: 19-819
NLF-C-502



1 NLF-C-503 **NORTHEAST CAP TERMINATION**
NTS

NOTES:

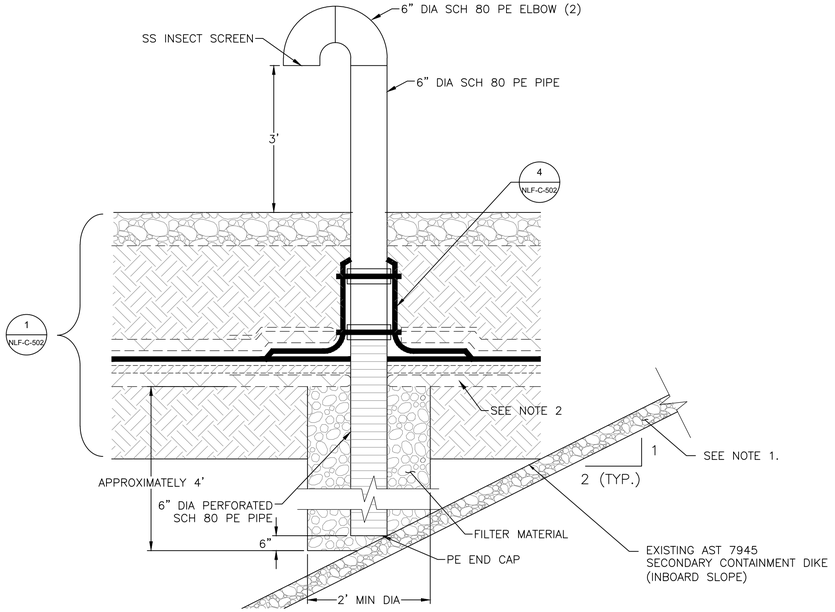
1. REMOVE INDICATED EXISTING COARSE AGGREGATE DIKE PROTECTIVE SURFACE LAYER. SALVAGE AND REUSE ELSEWHERE WITHIN NORTH LANDFARM LIMITS IF APPROVED BY ENGINEER.
2. PROVIDE ADDITIONAL 6 FOOT MINIMUM WIDTH GEOCOMPOSITE GAS VENTING LAYER (NOT SHOWN) ABOVE SINGLE-SIDED GEOCOMPOSITE GAS VENTING LAYER AT CAP TERMINATION LOCATION FOR FULL LENGTH OF NORTHEAST DIKE. PASSIVE GAS VENTS NOT SHOWN.
3. PROVIDE DOUBLE-SIDED (SHOWN) OR SINGLE-SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.



2 NLF-C-503 **NORTHWEST CAP TERMINATION**
NTS

NOTES:

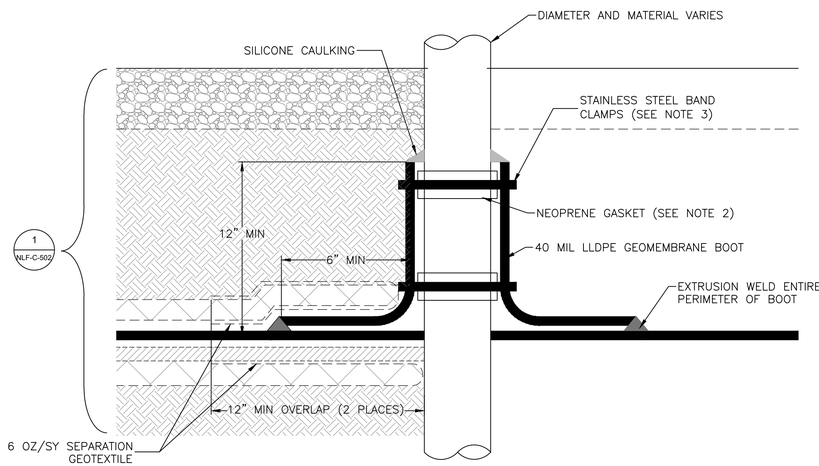
1. REMOVE INDICATED EXISTING COARSE AGGREGATE DIKE PROTECTIVE SURFACE LAYER. SALVAGE AND REUSE ELSEWHERE WITHIN NORTH LANDFARM LIMITS IF APPROVED BY ENGINEER.
2. PROVIDE DOUBLE-SIDED (SHOWN) OR SINGLE-SIDED GEOCOMPOSITE DRAINAGE LAYER WITHIN CAP LIMITS.



3 NLF-C-503 **PASSIVE GAS VENT**
NTS

NOTES:

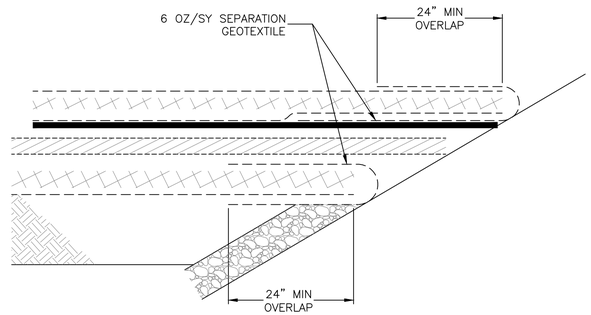
1. REMOVE INDICATED EXISTING COARSE AGGREGATE DIKE PROTECTIVE SURFACE LAYER. SALVAGE AND REUSE ELSEWHERE WITHIN NORTH LANDFARM LIMITS IF APPROVED BY ENGINEER.
2. PROVIDE ADDITIONAL 6 FOOT MINIMUM WIDTH GEOCOMPOSITE GAS VENTING LAYER (NOT SHOWN) ABOVE SINGLE-SIDED GEOCOMPOSITE GAS VENTING LAYER AT PEAK OF CAP ALONG NORTHEAST DIKE.



4 NLF-C-503 **GEOMEMBRANE BOOT**
NTS

NOTES:

1. PROVIDE FOR ALL PENETRATIONS THROUGH GEOMEMBRANE. GCL SHALL EXTEND COMPLETELY AROUND PENETRATION.
2. NEOPRENE GASKET TO BE PLACED BETWEEN THE GEOMEMBRANE BOOT AND PENETRATIONS, AND SHALL EXTEND BEYOND THE LOCATIONS OF THE STAINLESS STEEL BAND CLAMPS.
3. LOCATIONS OF STAINLESS STEEL BAND CLAMPS, NEOPRENE GASKET, AND LENGTH OF GEOMEMBANE BOOT MAY NEED TO BE "FIELD FIT".



5 NLF-C-503 **OVERLAP DETAIL - B**
NTS

NOTES:

1. REMOVED EXISTING COARSE AGGREGATE DIKE PROTECTIVE LAYER NOT SHOWN..

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24GA27961400

PLAN PREPARER:
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N.J. LICENSE NUMBER: GE38785

STATE OF NEW JERSEY · ALAN E. BRIGGS · No. GE38785 · PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: LZ	DATE: 08/14/19
CHKD: RCM	DATE: 08/23/19
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SCALE: AS SHOWN	

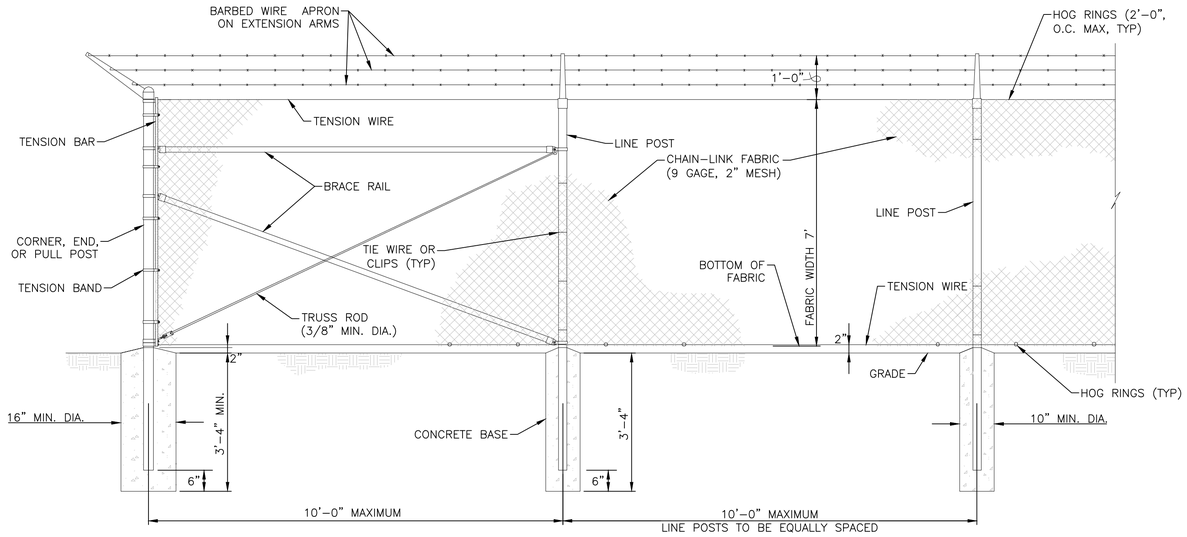
KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION-FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

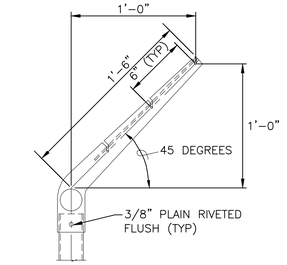
CAP DETAILS (SHEET 2 OF 2)

PROJECT NO: 19-819

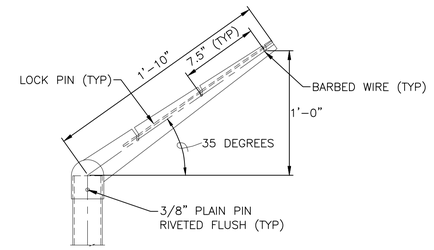
NLF-C-503



1 NLF-C-504 **CHAIN-LINK SECURITY FENCE DETAIL**
NTS



LINE POST



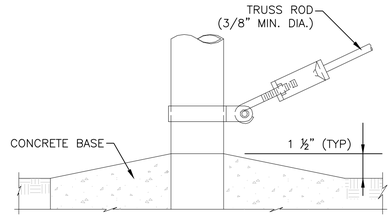
CORNER POST

5 NLF-C-504 **EXTENSION ARM DETAILS**
NTS

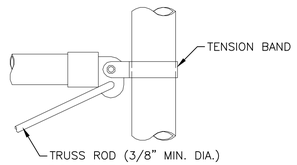
STEEL POST SCHEDULE			
USE AND SECTION	MINIMUM OUTSIDE DIMENSIONS (NOMINAL)		
	FABRIC LESS THAN 72"	FABRIC 72" TO 96"	FABRIC OVER 96"
CORNER END & PULL POSTS			
TUBULAR – ROUND	2.375" O.D.	2.875" O.D.	4.00" O.D.
TUBULAR – SQUARE	2.00" SQ.	2.50" SQ.	3.00" SQ.
C–SECTION (ROLL–FORMED)	3.50" X 3.50"	3.50" X 3.50"	————
LINE POSTS			
TUBULAR – ROUND	1.90" O.D.	2.375" O.D.	2.875" O.D.
H–SECTION	2.25" X 1.70"	2.25" X 1.70"	2.25" X 1.70"
C–SECTION (ROLL–FORMED)	1.875" X 1.625"	2.25" X 1.70"	————
TOP, BOTTOM & BRACE RAILS			
TUBULAR – ROUND	1.66" O.D.		
TUBULAR – SQUARE	1.50" O.D.		
H–SECTION	1.625" X 1.50"		
C–SECTION (ROLL–FORMED)	1.625" X 1.25"		

NOTES:

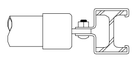
1. REFER TO DRAWING NLF–G–002 FOR GENERAL NOTES AND LEGEND.
2. DETAILS SHOWN ARE TO CLARIFY REQUIREMENTS AND ARE NOT INTENDED TO LIMIT OTHER TYPES OF FENCE SECTIONS AND METHODS OF INSTALLATION.
3. WIRE TIES, RAILS, POSTS, AND BRACES SHALL BE CONSTRUCTED ON THE SECURE SIDE OF THE FENCE ALIGNMENT. CHAIN–LINK FABRIC SHALL BE PLACED ON THE OPPOSITE SIDE OF THE SECURE AREA. UNLESS SPECIFICALLY SHOWN OR SPECIFIED, ALL FENCE SHALL HAVE AN APRON EXTENDED OUTWARD FROM THE AREA BEING PROTECTED. C–SECTION POSTS SHALL BE INSTALLED SO THAT THE VOID INSIDE THE POST IS COMPLETELY FILLED WITH CONCRETE UP TO THE TOP OF THE FOUNDATION.
4. GROUND FENCE ON EACH SIDE OF GATE AND AT EACH CORNER.



TRUSS ROD AND BAND

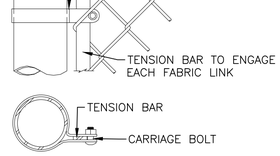


ROUND POST

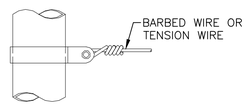


H–BEAM

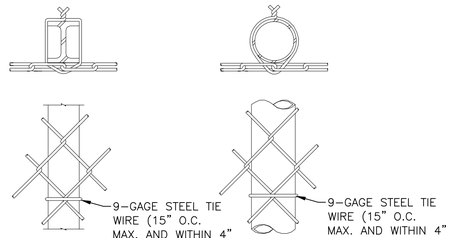
BRACE RAIL CLAMP DETAILS



END OR GATE POST DETAIL



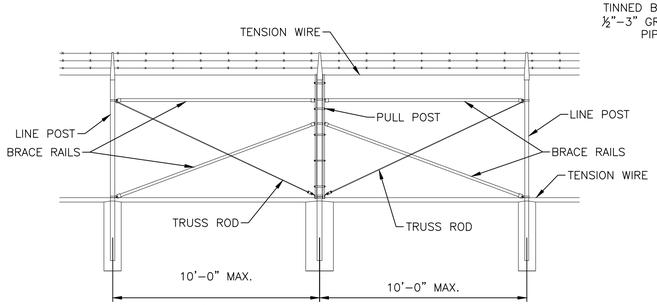
TENSION BAND DETAIL



H–BEAM ROUND POST

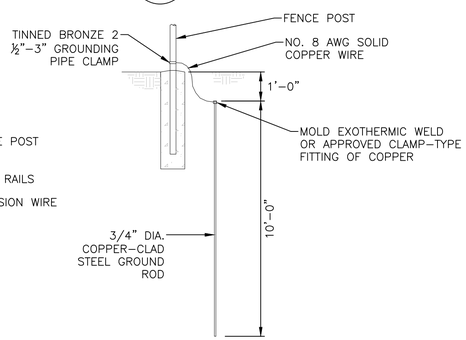
LINE POST ATTACHMENTS

2 NLF-C-504 **FASTENING DETAILS**
NTS



3 NLF-C-504 **BRACE PANEL DETAIL**
NTS

NOTE:
PROVIDE BRACE PANEL WHENEVER STRAIGHT RUNS EXCEED 500 FEET.



4 NLF-C-504 **GROUNDING DETAIL**
NTS

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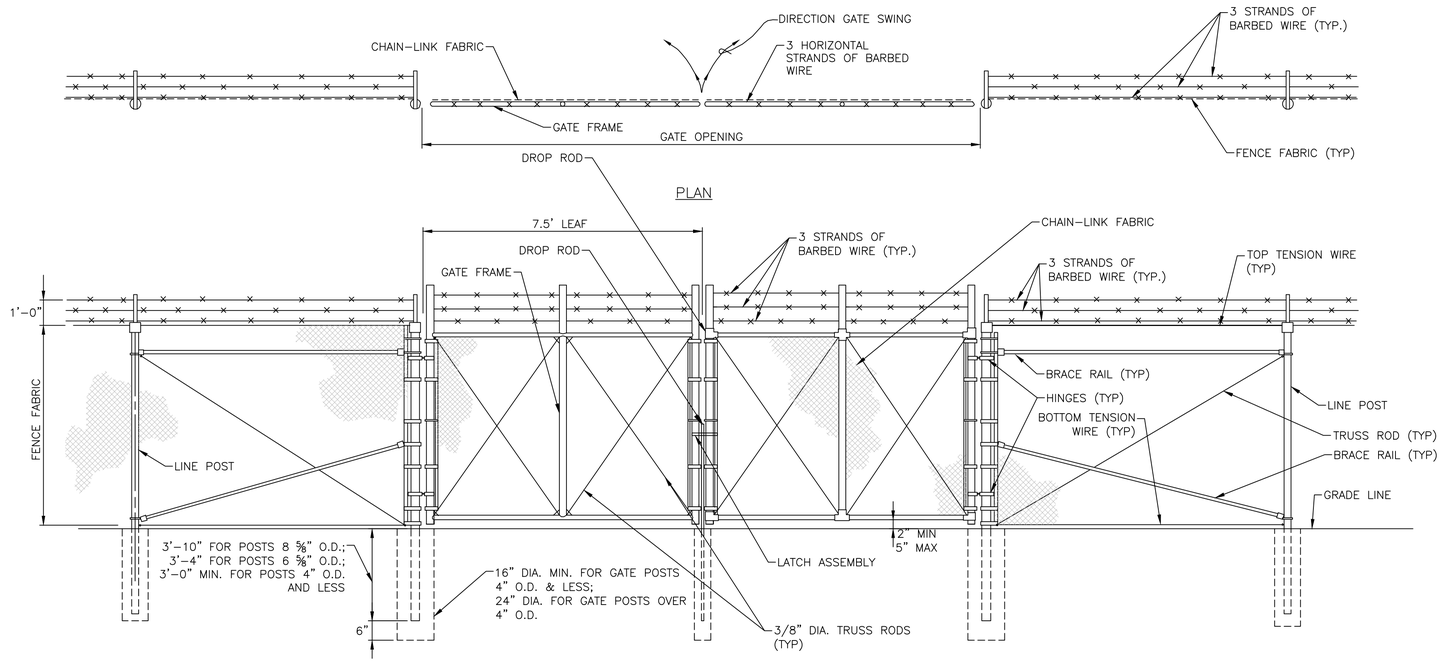
KEY ENVIRONMENTAL INCORPORATED

SOIL REMEDIAL ACTION DESIGN
AOC–1: NORTH LANDFARM
HESS CORPORATION–FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

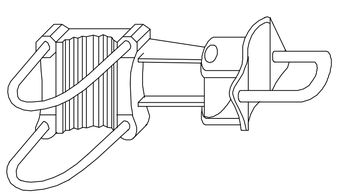
FENCE DETAILS
(SHEET 1 OF 2)

PROJECT NO: 19–819
NLF–C–504

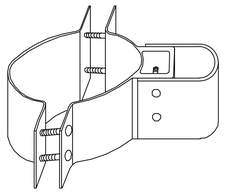


1 NLF-C-505 **DOUBLE SWING GATE**
NTS

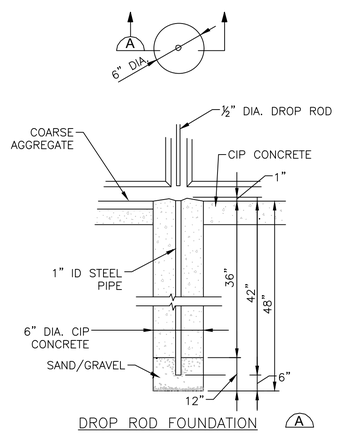
GATE POST SCHEDULE	
GATE LEAF WIDTH (NOMINAL)	OUTSIDE DIMENSION (NOMINAL)
6' OR LESS	2.875" O.D. 2.5" SQ
MORE THAN 6' TO 13'	4.0" O.D.
MORE THAN 13' TO 18'	6.625" O.D.
MORE THAN 18'	8.625" O.D.



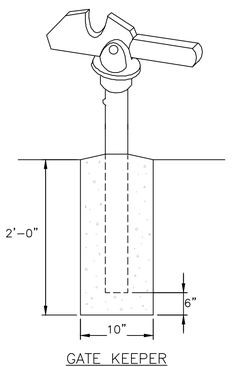
OFFSET HINGE



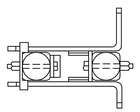
STANDARD HINGE

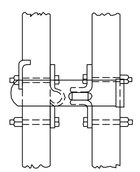


2 NLF-C-505 **DROP ROD FOUNDATION**
NTS

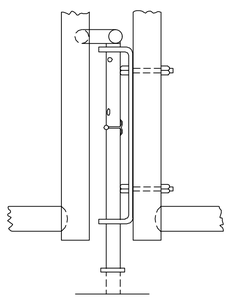


GATE KEEPER





LATCH ASSEMBLY



DROP ROD ASSEMBLY

3 NLF-C-505 **SWING GATE DETAILS**
NTS

NOTES:

1. REFER TO DRAWING NFL–G–002 FOR GENERAL NOTES AND LEGEND.
2. DETAILS SHOWN ARE TO CLARIFY REQUIREMENTS AND ARE NOT INTENDED TO LIMIT OTHER TYPE OF FENCE SECTIONS AND METHODS OF INSTALLATION.
3. SWING GATES SHALL BE CONSTRUCTED WITH DROP RODS, PADLOCKS, LATCH ASSEMBLY AND GATE KEEPERS EXCEPT AS NOTED.
4. ALL GATE FRAMES SHALL BE ASTM F900 A MINIMUM 1.9" NOMINAL (ROUND) OR 2.00" NOMINAL (SQUARE). GATE FRAMES SHALL BE OF WELDED CONSTRUCTION OR SHALL BE ASSEMBLED USING HEAVY FITTINGS. AT CONTRACTOR'S OPTION A WELDED HORIZONTAL BRACE MAY BE USED IN LIEU OF TRUSS RODS TO BRACE ALL WELDED GATE FRAMES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROPER RIGID CONSTRUCTION OF ALL GATES SUPPLIED.

REV #	DATE	DESCRIPTION	APPD

ISSUE DATE: 10/16/19

KEY ENVIRONMENTAL, INC.
200 THIRD AVENUE
CARNEGIE, PA 15106

STATE OF NEW JERSEY
CERTIFICATE OF AUTHORIZATION
TO OFFER ENGINEERING SERVICES
24GA27961400

PLAN PREPARER:
ALAN E. BRIGGS, PROFESSIONAL ENGINEER
N.J. LICENSE NUMBER, GE38785

STATE OF NEW JERSEY · ALAN E BRIGGS · No. GE38785 · PROFESSIONAL ENGINEER

SIGNATURE 10/16/19 DATE

EARTH SYSTEMS, INC.

DRWN: SCC	DATE: 08/14/19	KEY ENVIRONMENTAL INCORPORATED
CHKD: PAA	DATE: 08/23/19	
APPD: AEB	DATE: 08/23/19	
SCALE:	AS SHOWN	

SOIL REMEDIAL ACTION DESIGN
AOC–1: NORTH LANDFARM
HESS CORPORATION–FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

FENCE DETAILS
(SHEET 2 OF 2)

PROJECT NO: 19–819
NLF–C–505

APPENDIX D

TECHNICAL SPECIFICATIONS

DOCUMENT 00 01 15

LIST OF DRAWINGS

PART 1 GENERAL

1.1 SUMMARY

This section lists the drawings for the project.

1.2 REMEDIAL ACTION DESIGN DRAWINGS

Remedial Action Design drawings are as follows:

DRAWING NO.	TITLE	REVISION	DATE
NLF-G-001	Title Sheet	0	08/23/19
NLF-G-002	General Notes and Legend	0	08/23/19
NLF-G-003	Soil Erosion and Sediment Control Notes	0	08/23/19
NLF-C-101	Existing Site Conditions Plan	0	08/23/19
NLF-C-102	Soil Erosion and Sediment Control and Plan	0	08/23/19
NLF-C-103	Work Area Plan	0	08/23/19
NLF-C-104	Subgrade Grading Plan	0	08/23/19
NLF-C-105	Final Grading Plan	0	08/23/19
NLF-C-301	Cross-Sections	0	08/23/19
NLF-C-501	Soil Erosion and Sediment Control Details	0	08/23/19
NLF-C-502	Cap Details (Sheet 1 of 2)	0	08/23/19
NLF-C-503	Cap Details (Sheet 2 of 2)	0	08/23/19
NLF-C-504	Fence Details (Sheet 1 of 2)	0	08/23/19
NLF-C-505	Fence Details (Sheet 2 of 2)	0	08/23/19

1.3 SUPPLEMENTARY DRAWINGS

These supplementary drawings may not be a part of the contract but are included with the drawings for information.

1.3.1 Reference Drawings

The following reference drawings are intended only to show the original construction.

DRAWING NO.	TITLE	REVISION	DATE
Document titled “Remedial Action Workplan/Post-Closure Monitoring Plan, AOC-1: North Landfarm, Hess Corporation-Former Port Reading Complex (HC-PR), 750 Cliff Road, Port Reading, Middlesex County, New Jersey, NJDEP PI# 006148, ISRA Case No. E20130449, EPA ID No. NJD045445483”. Prepared for Hess Corporation, West Trenton, New Jersey. Prepared by Earth Systems. September 2016.			
Figure 3	Site Plan	- -	11/2015
Figure 5A	AOC-1 Historical Sample Location – Horizontal View	- -	11/2015
Figure 5B	AOC-1 Historical Sample Location – Vertical View	- -	11/2015

1.4 SUPPLEMENTARY REPORTS

The following reference reports are available for examination and are included for information.

1.4.1 Boring Logs

Engineer does not guarantee that borings indicate actual conditions, except for the exact locations and the time that they were made. Subsurface data, not specified or indicated, has been obtained by others. Boring logs are appended to the Soil Remedial Action Design Report.

1.4.2 Subsurface Data

Subsurface data, not specified or indicated, have been obtained by Engineer. The data are appended to the Soil Remedial Action Design Report.

-- End of Document --

SECTION 01 11 00

SUMMARY OF WORK

PART 1 GENERAL

1.1 WORK COVERED BY CONTRACT DOCUMENTS

1.1.1 Project Description

The work includes providing an engineered cap on AOC-1: North Landfarm, required to meet the closure performance standards specified in the Resource Conservation and Recovery Act and incidental related work.

1.1.2 Location

The work is located at the Hess Corporation - Former Port Reading Refining Facility in Port Reading, Middlesex County, New Jersey, approximately as indicated.

1.2 OCCUPANCY OF PREMISES

Buildings will be occupied and existing Site activities will continue during performance of work under this Contract. Notifications will be posted in a prominent location in the work area.

Before work is started, arrange with the Engineer a sequence of procedure, means of access, space for storage of materials and equipment, and use of approaches and parking.

1.3 EXISTING WORK

The Contractor shall preserve and protect all structures, equipment, and vegetation (such as trees, shrubs, and grass) on or adjacent to the work site, which are not to be removed and which do not unreasonably interfere with the work required under this Contract. The Contractor shall only remove trees and vegetation when specifically authorized to do so, and shall avoid damaging vegetation that will remain in place. If any limbs or branches of trees are broken during contract performance, or by the careless operation of equipment, or by workmen, the Contractor shall trim those limbs or branches with a clean cut and paint the cut with a tree pruning compound. In addition:

a. Remove or alter existing work in such a manner as to prevent injury or damage to any portions of the existing work which remain.

b. Repair or replace portions of existing work which have been altered during construction operations to match existing or adjoining work, as approved by the Engineer. At the completion of operations, existing work must be in a condition equal to or better than that which existed before new work started.

1.4 LOCATION OF UNDERGROUND UTILITIES

Obtain permits prior to start of work, and comply with installation requirements for locating and marking underground utilities. Contact New Jersey Call 811 Before You Dig and all pertinent local utility locating services a minimum of 72 hours prior to initiating work, to mark utilities, and within sufficient time required if work occurs on a Monday or after a Holiday. Verify existing utility locations indicated on contract drawings, within area of work.

Identify and mark all other utilities not managed and located by the local utility companies. Scan the construction site with ground penetrating radar (GPR), electromagnetic, or sonic equipment, and mark the surface of the ground or paved surface where existing underground utilities are discovered. Verify the elevations of existing piping, utilities, and any type of underground obstruction not indicated, or specified to be removed, that is indicated or discovered during scanning, in locations to be traversed by piping, ducts, and other work to be conducted or installed. Verify elevations before installing new work closer than nearest manhole or other structure at which an adjustment in grade can be made.

1.4.1 Notification Prior to Excavation

Notify the Engineer at least 72 hours prior to starting excavation work.

1.5 SALVAGE MATERIAL AND EQUIPMENT

Items designated by the Engineer to be salvaged remain the property of Hess. Segregate, itemize, deliver and off-load the salvaged property as indicated by the Engineer. Use a system of property control that is approved by the Engineer. Store and protect salvaged materials and equipment until disposition by the Engineer.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

Not used.

-- End of Section --

SECTION 02 56 13

WASTE CONTAINMENT GEOMEMBRANE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1004	(2013) Tear Resistance (Graves Tear) of Plastic Film and Sheeting
ASTM D1238	(2013) Melt Flow Rates of Thermoplastics by Extrusion Plastometer
ASTM D1505	(2010) Density of Plastics by the Density-Gradient Technique
ASTM D1603	(2014) Carbon Black Content in Olefin Plastics
ASTM D3895	(2014) Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry
ASTM D4218	(2015) Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
ASTM D4833	(2007; E 2013; R 2013) Index Puncture Resistance of Geomembranes and Related Products
ASTM D5199	(2012) Measuring the Nominal Thickness of Geosynthetics
ASTM D5321	(2017) Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
ASTM D5323	(1992; R 2011) Standard Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes
ASTM D5596	(2003; R 2016) Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

ASTM D5617	(2004; R 2015) Standard Test Method for Multi-Axial Tension Test for Geosynthetics
ASTM D5721	(2008; R 2013) Air-Oven Aging of Polyolefin Geomembranes
ASTM D5820	(1995; R 2018) Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D5885	(2017) Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry
ASTM D5994	(2010; R 2015; E2015) Standard Test Method for Measuring Core Thickness of Textured Geomembranes
ASTM D6370	(2014) Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
ASTM D6392	(2012; R 2018) Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D6497	(2002; R 2015; E 2015) Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures
ASTM D6693	(2004; E 2015) Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
ASTM D7238	(2006; R 2017) Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
ASTM D7466	(2010; E2015) Standard Test Method for Measuring Asperity Height of Textured Geomembranes
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GM7	(1995) Accelerated Curing of Geomembrane Test Strip Seams Made by Chemical Fusion Methods
GSI GRI GM9	(1995; R 2013) Cold Weather Seaming of Geomembranes

GSI GRI GM17	(2015; Rev 12, 11/4) Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GSI GRI GM19	(2015) Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes
GSI GRI GM20	(2003) Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using Control Charts

1.2 PANEL LAYOUT

Submit geomembrane panel layout and penetration detail drawings, a minimum of 7 days prior to geomembrane placement.

1.3 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an “NJDEP” or “EPA” designation require submittal to the New Jersey Department of Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-02 Shop Drawings

Geomembrane Panel Layout

Penetrations

Geomembrane panel layout and penetration detail drawings, a minimum of 14 days prior to geomembrane placement.

As-Built Drawings

Final as-built drawings of geomembrane installation.

Geomembrane boot and seal

Passive gas vents

SD-03 Product Data

Mechanical Anchoring Materials

Tests, Inspections, and Certifications

Manufacturer’s and fabricator’s QC manuals
A minimum of 14 days prior to geomembrane shipment.

Field Seaming

Installer’s QC manual
A minimum of 14 days prior to geomembrane placement.

Qualifications

Manufacturer’s and fabricator’s qualification statements including resumes of key personnel involved in the project, a minimum of 14 days prior to geomembrane shipment.

Installer’s, QC inspector’s, and QC laboratory’s qualification statements including resumes of key personnel involved in the project a minimum of 14 days prior to geomembrane placement. The submittal from the QC laboratory shall include verification that the laboratory is accredited via the Geosynthetic Accreditation Institute’s Laboratory Accreditation Program (GAI-LAP) for the tests the QC laboratory will be required to perform.

SD-04 Samples

Samples

Geomembrane QA and QC samples

SD-06 Test Reports

Surface Preparation

Certification from the QC inspector and installer of the acceptability of the surface on which the geomembrane is to be placed, immediately prior to geomembrane placement.

Non-Destructive Field Seam Continuity Testing

QC inspector certified test results on all field seams.

Destructive Field Seam Testing

Installer and certified QC laboratory test results on all destructively tested field seams.

Destructive Seam Test Repairs

QC inspector certified test results on all repaired seams.

Interface Friction Testing

Certified laboratory interface friction test results including description of equipment and test method or Manufacturer’s certified test results, a minimum of 14 days prior to geomembrane shipment.

Tests

Certified QC test results

SD-07 Certificates

Samples

Materials

Surface Preparation

Destructive Field Seam Testing

Destructive Seam Test Repairs

Tests

1.4 QUALITY CONTROL

1.4.1 Qualifications

1.4.1.1 Manufacturer

Manufacturer shall have produced the proposed geomembrane sheets for at least 5 completed projects having a total minimum area of 10 million square feet.

1.4.1.2 Fabricator

The fabricator is responsible for seaming geomembrane sheets into panels. Fabricator shall have fabricated the proposed geomembrane panels for at least 5 completed projects having a total minimum area of 2 million square feet.

1.4.1.3 Installer

The installer is responsible for field handling, deploying, seaming, anchoring, and field Quality Control (QC) testing of the geomembrane. The installer shall have installed the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet. At least one seamer shall have experience seaming a minimum of 500,000 square feet of the proposed geomembrane using the same type of seaming equipment and geomembrane thickness specified for this project.

1.4.1.4 QC Inspector

The QC inspector is the person or corporation hired by the Contractor, who is responsible for monitoring and documenting activities related to the QC of the geomembrane from manufacturing through installation. The QC inspector shall have provided QC inspection during installation of the proposed geomembrane material for at least 5 completed projects having a total minimum area of 2 million square feet.

1.4.1.5 QC Laboratory

The QC laboratory shall have provided QC and/or Quality Assurance (QA) testing of the proposed geomembrane and geomembrane seams for at least five completed projects having a total minimum area of 2 million square feet. The QC laboratory shall be accredited via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests the QC laboratory will be required to perform.

1.5 DELIVERY, STORAGE AND HANDLING

1.5.1 Delivery

The QC inspector shall be present during delivery and unloading of the geomembrane. Each geomembrane roll/panel shall be labeled with the Manufacturer's name, product identification number, roll/panel number, and roll dimensions.

1.5.2 Storage

Temporary storage at the project site shall be on a level surface, free of sharp objects where water cannot accumulate. The geomembrane shall be protected from puncture, abrasion, excessive heat or cold, material degradation, or other damaging circumstances. Storage shall not result in crushing the core of roll goods or flattening of the rolls. Rolls shall not be stored more than two high. Damaged geomembrane shall be removed from the site and replaced with geomembrane that meets the specified requirements.

1.5.3 Handling

Rolls/panels shall not be dragged, lifted by one end, or dropped. A pipe or solid bar, of sufficient strength to support the full weight of a roll without significant bending, shall be used for all handling activities. The diameter of the pipe or solid bar shall be small enough to be easily inserted through the core of the roll. Chains shall be used to link the ends of the pipe or bar to the ends of a spreader bar. The spreader bar shall be wide enough to prevent the chains from rubbing against the ends of the roll. Alternatively, a stinger bar protruding from the end of a forklift or other equipment may be used. The stinger bar shall be at least three-fourths the length of the core and also must be capable of supporting the full weight of the roll without significant bending. If recommended by the Manufacturer, a sling handling method utilizing appropriate loading straps may be used.

1.6 AMBIENT CONDITIONS

Geomembrane shall not be deployed or field-seamed in the presence of excess moisture (i.e., rain, fog, dew), in areas of ponded water, or in the presence of excess wind. No placement or seaming shall be attempted at ambient temperatures below 32 degrees F or above 104 degrees F. Ambient temperature shall be measured at a height no greater than 6 inches above the ground or geomembrane surface. If seaming is allowed below 32 degrees F, the procedures outlined in GSI GRI GM9 shall be followed. In marginal conditions, seaming shall cease unless destructive field seam tests, conducted by the QC laboratory, confirm that seam properties meet the requirements listed in Table 3. Tests shall be conducted in accordance with paragraph Destructive Field Seam Testing.

1.7 EQUIPMENT

Equipment used in performance of the work shall be in accordance with the geomembrane Manufacturer’s recommendations and shall be maintained in satisfactory working condition.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Raw Materials

Resin used in manufacturing geomembrane sheets shall be made of virgin uncontaminated ingredients with a density of 0.926 g/ml measured in accordance with ASTM D1505 or ASTM D792 Method B, and a melt index value of less than 1.0 g/10 minutes measured in accordance with ASTM D1238. No more than 10 percent regrind, reworked, or trim material in the form of chips or edge strips shall be used to manufacture the geomembrane sheets. All regrind, reworked, or trim materials shall be from the same manufacturer and exactly the same formulation as the geomembrane sheet being produced. No post consumer materials or water-soluble ingredients shall be used to produce the geomembrane. For geomembranes with plasticizers, only primary plasticizers that are resistant to migration shall be used. Submit a copy of the test reports and QC certificates for materials used in the manufacturing of the geomembrane shipped to the site.

2.1.2 Sheet Materials

Geomembrane sheets shall be unreinforced and manufactured as wide as possible to minimize factory and field seams. Geomembrane sheets shall be uniform in color, thickness, and surface texture. Geomembrane shall be smooth or textured as indicated. The textured surface features shall consist of raw materials identical to that of the parent sheet material and shall be uniform over the entire face of the geomembrane. The sheets shall be free of and resistant to fungal or bacterial attack and free of cuts, abrasions, holes, blisters, contaminants and other imperfections. Geomembrane sheets and factory seams shall conform to the requirements listed in Tables 1 and 2 for Manufacturing Quality Control (MQC).

TABLE 1
SMOOTH LLDPE GEOMEMBRANE PROPERTIES

PROPERTY	TEST VALUE	MQC TESTING FREQUENCY (MIN.)	TEST METHOD
Thickness (min ave)	40.0 mils	per roll	ASTM D5199
Lowest individual of 10 values	36.0 mils	per roll	ASTM D5199
Density (max)	0.939 g/ml	per 200,000 lb	ASTM D1505/ASTM D792
Tensile Properties(1)(min ave)		per 20,000 lb	ASTM D6693 Type IV
- break stress	152 lb/in		
- break elongation	800 percent		
2% Modulus (max)	2400 lb/in	per formulation	ASTM D5323
Tear Resistance (min ave)	22 lb	per 45,000 lb	ASTM D1004

TABLE 1
SMOOTH LLDPE GEOMEMBRANE PROPERTIES

PROPERTY	TEST VALUE	MQC TESTING FREQUENCY (MIN.)	TEST METHOD
Puncture Resistance (min ave)	56 lb	per 45,000 lb	ASTM D4833
Axi-Symmetric Break Resistance Strain (min)	30 percent	per formulation	ASTM D5617
Carbon Black Content	2.0-3.0 percent	per 45,000 lb	ASTM D4218 (2)
Carbon Black Dispersion	Note (3)	per 45,000 lb	ASTM D5596
Oxidative Induction Time (OIT)(4)		per 200,000 lb	
- Standard OIT (min ave)	100 min		ASTM D3895
- High Pressure OIT (min ave)	400 min		ASTM D5885
Oven Aging at 185 degrees F (5)		per year and change in formulation	ASTM D5721
- Standard OIT (min ave) or	35 percent retained after 90 days		ASTM D3895
- High Pressure OIT (min ave)	60 percent retained after 90 days		ASTM D5885
UV Resistance (min ave) (6)		per year and change in formulation	ASTM D7238
High Pressure OIT(7)	35 percent retained after 1600 hours		ASTM D5885

TABLE 2
TEXTURED LLDPE GEOMEMBRANE PROPERTIES

PROPERTY	TEST VALUE	MQC TESTING FREQUENCY (MIN.)	TEST METHOD
Nominal Thickness	40 mils		
Thickness (min ave)	38.0 mils	per roll	ASTM D5994

TABLE 2
TEXTURED LLDPE GEOMEMBRANE PROPERTIES

PROPERTY	TEST VALUE	MQC TESTING FREQUENCY (MIN.)	TEST METHOD
Lowest individual for 8 out of 10 values	36.0 mils	per roll	ASTM D5994
Lowest individual of 10 values	34.0 mils	per roll	ASTM D5994
Asperity Height (min ave) (8)(10)	16 mils	every second roll	ASTM D7466 (9)
Density (max)	0.939 g/ml	per 200,000 lb	ASTM D1505/ASTM D792
Tensile Properties (1)(min ave)		per 20,000 lb	ASTM D6693 Type IV
- break strength	60 lb/in		
- break elongation	250 percent		
2% Modulus (max)	2400 lb/in	per formulation	ASTM D5323
Tear Resistance (min ave)	22 lb	per 45,000 lb	ASTM D1004
Puncture Resistance (min ave)	44 lb	per 45,000 lb	ASTM D4833
Axi-Symmetric Break Resistance Strain (min)	30 percent	per formulation	ASTM D5617
Carbon Black Content	2.0-3.0 percent	per 45,000 lb	ASTM D4218 (2)
Carbon Black Dispersion	Note (3)	per 45,000 lb	ASTM D5596
Oxidative Induction Time (OIT)(4)		per 200,000 lb	
- Standard OIT)(min ave) or	100 min		ASTM D3895
- High Pressure OIT)(min ave)	400 min		ASTM D5885
Oven Aging at 185 degrees F (5)		per year and change in formulation	ASTM D5721
Standard OIT (min ave) or	35 percent retained after 90 days		ASTM D3895
- High Pressure OIT (min ave)	60 percent retained after 90 days		ASTM D5885

TABLE 2 TEXTURED LLDPE GEOMEMBRANE PROPERTIES			
PROPERTY	TEST VALUE	MQC TESTING FREQUENCY (MIN.)	TEST METHOD
UV Resistance (6)		per year and change in formulation	ASTM D7238
- High Pressure OIT (min ave) (7)	35 percent retained after 1600 hours	per formulation	ASTM D5885

TABLE 1 AND TABLE 2 NOTES	
MQC	Manufacturing Quality Control
Note (1)	Machine direction and cross machine direction average values shall be based on 5 test specimens in each direction. For LLDPE geomembrane, break elongation is calculated using a gage length of 2.0 inches at 2 inches/minute.
Note (2)	Other methods such as ASTM D1603 (tube furnace) or ASTM D6370 (thermogravimetric analysis) are acceptable if an appropriate correlation to ASTM D4218 (muffle furnace) can be established.
Note (3)	Carbon black dispersion (near spherical agglomerates only) for 10 different views: - minimum 9 of 10 in Categories 1 or 2 - all 10 in Categories 1, 2, or 3
Note (4)	The Manufacturer has the option to select either one of the OIT methods to evaluate the antioxidant content.
Note (5)	Evaluate samples at 30 and 60 days and compare with the 90 day response.
Note (6)	The condition of the test shall be a 20 hour UV cycle at 167 degrees F followed by a 4 hour condensation cycle at 140 degrees F.
Note (7)	UV resistance is based on percent retained value regardless of the original HP-OIT value.
Note (8)	Of 10 readings; 8 out of 10 must be greater than or equal to 7 mils, and lowest individual reading must be greater than or equal to 5 mils.
Note (9)	Alternate the measurement side for double sided textured sheet.
Note (10)	Test properties at minimum frequencies indicated or in accordance with the approved MQC manual, whichever is more stringent.
Note (11)	Table 1 and 2 values meet GSI GRI GM17.

TABLE 3 LLDPE SEAM PROPERTIES		
PROPERTY	TEST VALUE	TEST METHOD
Hot Wedge Fusion Seams		
Seam Shear Strength (min) (1)(4)	60 lb/in	ASTM D6392
Seam Shear Elongation (min) (2)	50 percent	ASTM D6392 and GSI GRI GM19
Seam Peel Strength (min) (1)(4)(5)	50 lb/in	ASTM D6392
Seam Peel Separation (max) (3)	25 percent	ASTM D6392 and GSI GRI GM19
Extrusion Fillet Welded Seams		
Seam Shear Strength (min) (1)(4)	60 lb/in	ASTM D6392
Seam Shear Elongation (min) (2)	50 percent	ASTM D6392 and GSI GRI GM19
Seam Peel Strength (min) (1)(4)	44 lb/in	ASTM D6392
Seam Peel Separation (max) (3)	25 percent	ASTM D6392 and GSI GRI GM19
TABLE 3 NOTES		
Note (1): Seam shear and seam peel strength of 4 out of 5 1.0 inch wide strip specimens greater than or equal to the test value. Seam shear and seam peel strength of fifth specimen greater than or equal to 80 percent of the test value.		
Note (2): Seam shear elongation of 5 out of 5 specimens greater than or equal to the test value. Elongation measurements may be omitted for field testing.		
Note (3): Seam peel separation (or incursion) of 5 out of 5 specimens less than or equal to the test value.		
Note (4): Per their description in ASTM D6392, Separation-in-plane (SIP) is an acceptable break code; AD and AD-Brk greater than 25 percent are unacceptable break codes for fusion welded seams; AD1 and AD2 are unacceptable break codes for extrusion fillet welded seams; and AD-WLD is an unacceptable break code unless the strength test value is met. Five out of 5 specimens shall result in acceptable break patterns.		
Note (5): Both tracks of double wedge fusion seam shall be tested.		

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Interface Friction Testing

Interface friction tests shall be conducted in accordance with ASTM D5321. Normal stresses of 1.0, 1.5, and 3.0 psi along with a displacement rate of 0.04 inches per minute shall be used. Interfaces shall be saturated for a minimum of 24 hours prior to testing. Soil components shall be the same as used for full scale construction and shall be compacted to the same moisture-density requirements specified for full scale field placement. Geosynthetics shall be the same materials as those proposed for use during

full scale construction. Geosynthetics shall be oriented such that the shear force is parallel to the down slope orientation of these components in the field.

For the flatter (4 percent) plateau portion of the cap a minimum residual shear strength of 23.5 pounds per square foot at a normal load of 1.7 pounds per square inch is required for all interfaces. If the proposed upper geotextile of the geosynthetic clay liner is a woven geotextile then conduct interface friction tests for 1) the upper woven geotextile component of the geosynthetic clay liner and smooth LLDPE geomembrane interface, and 2) the upper woven geotextile component of the geosynthetic clay liner and textured LLDPE geomembrane interface.

For the 3H:1V sideslope portion of the cap a minimum residual shear strength of 24.8 pounds per square foot at a normal load of 0.5 pounds per square inch is required for all interfaces. Conduct interface friction tests for Common Fill and 6 ounce per square yard nonwoven needle-punched Separation Geotextile interface.

Manufacturer’s certified test results using the same geosynthetic materials, similar soil, and the same test procedures and conditions may be used in lieu of site-specific interface friction testing subject to Engineer approval.

Textured geomembrane material subjected to interface friction testing shall be tested for asperity height in accordance with ASTM D7466. A portion of that geomembrane material test sample shall be provided to Engineer for approval.

2.2.2 Manufacturing, Sampling, and Testing

2.2.2.1 Raw Materials

Raw materials shall be tested in accordance with the approved MQC manual. Any raw material which fails to meet the geomembrane Manufacturer's specified physical properties shall not be used in manufacturing the sheet. Seaming rods and pellets shall be manufactured of materials which are essentially identical to that used in the geomembrane sheet. Seaming rods and pellets shall be tested for density, melt index and carbon black content in accordance with the approved MQC manual. Seaming rods and pellets which fail to meet the corresponding property values required for the sheet material shall not be used for seaming.

2.2.2.2 Material

Geomembrane sheets shall be tested in accordance with the approved MQC manual. As a minimum, MQC testing shall be conducted at the frequencies shown in Tables 1 and 2. Rolls not meeting the minimum requirements specified in Table 1 shall not be sent to the site.

2.3 MECHANICAL ANCHORING MATERIALS

As indicated. Provide information if alternative materials are proposed.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Surface Preparation

Surface preparation shall be performed in accordance with Section 31 23 00 EXCAVATION AND FILL. Rocks larger than 1/4 inch in diameter and any other material which could damage the geomembrane shall be removed from the surface to be covered with the geomembrane. Construction equipment tire or track deformations beneath the geomembrane shall not be greater than 1.0 inch in depth. Each day during placement of geomembrane, the QC Inspector and installer shall inspect the surface on which geomembrane is to be placed and certify in writing that the surface is acceptable.

3.1.2 Anchor Trenches

Unless otherwise indicated, anchor trenches shall be placed 24 inches back from the edge of the slope to be covered, shall be 12 inches deep and 12 inches wide, and the geomembrane shall extend down the front wall and across the bottom of the anchor trench. If the anchor trench is excavated in cohesive soil susceptible to desiccation, only the amount of anchor trench required for placement of geomembrane in a single day shall be excavated. Ponded water shall be removed from the anchor trench while the trench is open. Trench corners shall be slightly rounded to avoid sharp bends in the geomembrane. Loose soil, rocks larger than 1/4 inch in diameter, and any other material which could damage the geomembrane shall be removed from the surfaces of the trench. Backfilling and compaction of the anchor trench shall be in accordance with Section 31 23 00 EXCAVATION AND FILL.

3.2 CONTRACTOR'S RESTRICTIONS

No equipment or tools shall be used that damage the geosynthetic materials by handling, trafficking or other means. No personnel working on the geosynthetic materials shall smoke, wear damaging footwear or engage in other activities that can damage the geosynthetic materials. The method used to deploy the geosynthetic materials shall not disturb pipes, backfill, underlying geosynthetics, or surface to receive geomembrane.

The storage of fuel oils and other petroleum products shall be restricted to off cap areas and shall not be located adjacent to or immediately upgradient of geosynthetic covered areas. Equipment maintenance (fueling, replacing oil and filters, etc.) shall not take place on cap areas. Any leakage of petroleum products shall be immediately removed from the geosynthetic covered areas.

The QC Inspector shall visually observe each panel, after placement and prior to seaming for damage. The QC Inspector shall determine which panels or portions of panels shall be rejected, repaired or accepted. Damaged panels or portions of panels which have been rejected shall be marked and their removal or repair recorded by the QC Inspector.

3.3 GEOMEMBRANE DEPLOYMENT

The procedures and equipment used shall not elongate, wrinkle, scratch, or otherwise damage the geomembrane, other geosynthetic layers, or the underlying subgrade. Geomembrane damaged during installation shall be

replaced or repaired, at the QC inspector's discretion. Only geomembrane panels that can be anchored and seamed together the same day shall be deployed. Adequate ballast (i.e., sand bags) shall be placed on the geomembrane, without damaging the geomembrane, to prevent uplift by wind. No equipment shall be operated on the top surface of the geomembrane without permission from the Engineer and QC Inspector. Seams shall be oriented parallel to the line of maximum slope. Where seams can only be oriented across the slope, the upper panel shall be lapped over the lower panel. The methods used to deploy and backfill over the geomembrane shall minimize wrinkles and tensile stresses in the geomembrane. The geomembrane shall have adequate slack to prevent the creation of tensile stress. The wrinkle height to width ratio for installed geomembrane shall not exceed 0.5. In addition, geomembrane wrinkles shall not exceed 6 inches in height. Wrinkles that do not meet the above criteria shall be cut out and repaired in accordance with the installer's approved QC manual.

3.4 FIELD SEAMING

3.4.1 Trial Seams

Trial seams shall be made under field conditions on strips of excess geomembrane. Trial seams shall be made each day prior to production seaming, whenever there is a change in seaming personnel or seaming equipment and at least once every four hours, by each seamer and each piece of seaming equipment used that day. Trial seam samples shall be collected and tested in accordance with ASTM D6392. One sample shall be obtained from each trial seam. This sample shall be at least 36 inches long by 12 inches wide with the seam centered lengthwise. Ten random specimens 1 inch wide shall be cut from the sample. Five seam specimens shall be field tested for shear strength and 5 seam specimens shall be field tested for peel adhesion using an approved quantitative tensiometer. Where necessary, accelerated curing of trial seams made by chemical methods shall be conducted in accordance with GSI GRI GM7. To be acceptable, 4 out of 5 replicate test specimens shall meet seam strength requirements specified in Table 3. If the field tests fail to meet these requirements, the entire operation shall be repeated. If the additional trial seam fails, the seaming apparatus or seamer shall not be used until the deficiencies are corrected by the installer and 2 consecutive successful trial seams are achieved.

3.4.2 Field Seams

Panels shall be seamed in accordance with the geomembrane Manufacturer's recommendations. In sumps, corners and odd-shaped geometric locations, the number of field seams shall be minimized. Seaming shall extend to the outside edge of panels. Soft subgrades shall be compacted and approved prior to seaming. The seam area shall be free of moisture, dust, dirt, and foreign material at the time of seaming. Fish mouths in seams shall be repaired. The following information shall be recorded for each seam:

1. Panel number
2. Seam number
3. Date and time seam was constructed
4. Temperature of geomembrane at time of seaming
5. Seaming unit designation
6. Name of seamer
7. Seaming equipment temperature and pressures

3.4.2.1 Polyethylene Seams

Polyethylene geomembranes shall be seamed by thermal fusion methods. Extrusion welding shall only be used for patching and seaming in locations where thermal fusion methods are not feasible. Seam overlaps that are to be attached using extrusion welds shall be ground prior to welding. Grinding marks shall be oriented perpendicular to the seam direction and no marks shall extend beyond the extrudate after placement. Extrusion welding shall begin within 10 minutes after grinding. Where extrusion welds are temporarily terminated long enough to cool, they shall be ground prior to applying new extrudate over the existing seam. The total depth of the grinding marks shall be no greater than 10 percent of the sheet thickness.

3.5 SAMPLES

A minimum of one QC sample per material type per lot per project or per every 100,000 square feet of material delivered to the site whichever results in the greater number of samples. One QC sample, 18 inches in length, for the entire width of a roll, shall be obtained for every 100,000 square feet of material delivered to the site. Samples shall not be obtained from the first three feet of the roll. For accordion folded geomembranes, samples of equivalent size shall be collected from approved locations. The samples shall be identified by Manufacturer's name, product identification, lot and roll/panel number. The date, a unique sample number, and the machine direction shall also be noted. In addition, a 12 inch by 12 inch QA sample shall be collected, labeled, and submitted to the Engineer each time QC samples are collected.

3.6 TESTS

Provide all QC samples to the QC laboratory to determine density, thickness, tensile strength at break, and elongation at break in accordance with the methods specified in Tables 1 and 2. Samples not meeting the specified requirements shall result in the rejection of applicable rolls/panels. As a minimum, rolls/panels produced immediately prior to and immediately after the failed roll/panel shall be tested for the same failed parameter. Testing shall continue until a minimum of three successive rolls/panels on both sides of the original failing roll/panel pass the failed parameter.

3.6.1 Non-Destructive Field Seam Continuity Testing

Field seams shall be non-destructively tested for continuity over their full length in accordance with the installer's approved QC manual. At a minimum, field seams created using a dual hot wedge fusion welder shall be tested by air channel pressure testing in accordance with ASTM D5820. Seam testing shall be performed as the seaming work progresses, not at the completion of field seaming. Any seams which fail shall be documented and repaired in accordance with the installer's approved QC manual.

3.6.2 Destructive Field Seam Testing

A minimum of one destructive test sample per 500 feet of field seam shall be obtained at locations specified by the QC inspector and Engineer. Sample locations shall not be identified prior to seaming. Samples shall be a minimum of 12 inches wide by 42 inches long with the seam centered lengthwise. Each sample shall be cut into 3 equal pieces, with one piece retained by the installer, one piece given to the QC laboratory, and the

remaining piece given to the Engineer for QA testing and/or permanent record. Each sample shall be numbered and cross referenced to a field log which identifies: (1) panel number; (2) seam number; (3) date and time cut; (4) ambient temperature within 6 inches above the geomembrane; (5) seaming unit designation; (6) name of seamer; and (7) seaming apparatus temperature and pressures (where applicable). Ten 1 inch wide replicate specimens shall be cut from the installer's sample. Five specimens shall be tested for shear strength and 5 for peel adhesion using an approved field quantitative tensiometer. Jaw separation speed shall be in accordance with the approved QC manual. To be acceptable, 4 out of 5 replicate test specimens shall meet the seam strength requirements specified in Table 3. If the field tests pass, 5 specimens shall be tested at the QC laboratory for shear strength and 5 for peel adhesion in accordance with the QC laboratory's approved procedures. To be acceptable, 4 out of 5 replicate test specimens shall meet the seam strength requirements specified in Table 3. If the field or laboratory tests fail, the seam shall be repaired in accordance with paragraph Destructive Seam Test Repairs. Holes for destructive seam samples shall be repaired the same day they are cut.

3.7 DEFECTS AND REPAIRS

3.7.1 Destructive Seam Test Repairs

Seams that fail destructive seam testing may be overlaid with a strip of new material and seamed (cap stripped). Alternatively, the seaming path shall be retraced to an intermediate location a minimum of 10 feet on each side of the failed seam location. At each location a 12 by 18 inch minimum size seam sample shall be taken for 2 additional shear strength and 2 additional peel adhesion tests using an approved quantitative field tensiometer. If these tests pass, then the remaining seam sample portion shall be sent to the QC laboratory for 5 shear strength and 5 peel adhesion tests in accordance with the QC laboratory's approved procedures. To be acceptable, 4 out of 5 replicate test specimens must meet specified seam strength requirements. If these laboratory tests pass, then the seam shall be cap stripped or repaired using other approved methods between that location and the original failed location. If field or laboratory tests fail, the process shall be repeated. After repairs are completed, the repaired seam shall be non-destructively tested in accordance with paragraph Non-Destructive Field Seam Continuity Testing.

3.7.2 Patches

Tears, holes, blisters and other defects shall be repaired with patches. Patches shall have rounded corners, be made of the same geomembrane, and extend a minimum of 6 inches beyond the edge of defects. Minor localized flaws shall be repaired by spot welding or seaming as determined by the QC inspector. Repairs shall be non-destructively tested. The Engineer or the QC inspector may also elect to perform destructive seam tests on suspect areas.

3.8 VISUAL INSPECTION AND EVALUATION

Immediately prior to covering, the geomembrane, seams, and non-seam areas shall be visually inspected by the QC inspector and Engineer for defects, holes, or damage due to weather conditions or construction activities. At the Engineer’s or the QC inspector's discretion, the surface of the geomembrane shall be brushed, blown, or washed by the installer if the

amount of dust, mud, or foreign material inhibits inspection or functioning of the overlying material. Each suspect location shall be non-destructively tested in accordance with paragraph Non-Destructive Field Seam Continuity Testing. Each location that fails non-destructive testing shall be repaired in accordance with paragraph Patches and non-destructively retested.

3.9 PENETRATIONS

Geomembrane penetration details shall be in accordance with ASTM D6497, as recommended by the geomembrane Manufacturer, or as otherwise indicated subject to Engineer approval. Factory fabricated boots shall be used wherever possible. Field seams for penetrations shall be non-destructively tested in accordance with the installer's approved QC manual. Seams that fail non-destructive testing shall be repaired in accordance with the installer's approved QC manual and non-destructively tested prior to acceptance.

3.10 PROTECTION AND BACKFILLING

The deployed and seamed geomembrane shall be covered with the specified material within 14 calendar days of acceptance. Wrinkles in the geomembrane shall be prevented from folding over during placement of cover materials. Cover soil shall not be dropped onto the geomembrane or overlying geosynthetics from a height greater than 3 feet. The soil shall be pushed out over the geomembrane or overlying geosynthetics in an upward tumbling motion. Cover materials shall be placed from the bottom of the slope upward. The initial loose cover material thickness shall result in a minimum initial lift thickness of 6 inches. Equipment ground pressure limits and cover thickness shall be as follows:

COVER THICKNESS (minimum)	EQUIPMENT GROUND PRESSURE (maximum)
6 inches	5.0 psi
12 inches	6.0 psi
18 inches	7.5 psi
24 inches	8.0 psi

The initial list of cover material placed above the geomembrane shall be compacted in a systematic manner to ensure 100 percent coverage is provided. Compact areas not accessible to large scale construction equipment and materials including aggregates with mechanical hand tampers in a systematic manner to ensure 100 percent coverage is provided. Density testing requirements may be waived by the Engineer provided the lift or area provides a stable and firm surface. Cover soil compaction and testing requirements are described in Section 32 23 00 EXCAVATION AND FILL. Equipment placing cover materials shall not stop abruptly make sharp turns, spin their wheels, or travel at speeds exceeding 5 mph.

3.11 AS-BUILT DRAWINGS

Submit final as-built drawings of the geomembrane installation. These drawings shall include panel numbers, seam numbers, location of repairs, destructive seam samples, and penetrations.

-- End of Section --

SECTION 02 56 15

GEOSYNTHETIC CLAY LINER (GCL)

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1505	(2010) Density of Plastics by the Density-Gradient Technique
ASTM D5199	(2012) Measuring Nominal Thickness of Geosynthetics
ASTM D5261	(2010) Measuring Mass Per Unit Area of Geotextiles
ASTM D5887	(2016) Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter
ASTM D5888	(2006; R 2016) Standard Guide for Storage and Handling of Geosynthetic Clay Liners
ASTM D5889	(2016) Standard Practice for Quality Control of Geosynthetic Clay Liners
ASTM D5890	(2011) Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
ASTM D5891	(2002; R 2016; E 2016) Fluid Loss of Clay Component of Geosynthetic Clay Liners
ASTM D5993	(2014) Measuring Mass Per Unit of Geosynthetic Clay Liners
ASTM D5994	(2010; R 2015; E2015) Standard Test Method for Measuring Core Thickness of Textured Geomembranes
ASTM D6072	(2009; R 2015) Obtaining Samples of Geosynthetic Clay Liners
ASTM D6243	(2016) Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

ASTM D6496	(2004a; R 2015; E 2015) Standard Test Method for Determining Average Bonding Peel Strength Between Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
ASTM D6768	(2004; R 2015; E 2015; E 2015) Standard Test Method for Tensile Strength of Geosynthetic Clay Liners
ASTM D792	(2013) Density and Specific Gravity (Relative Density) of Plastics by Displacement

1.2 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an “NJDEP” or “EPA” designation require submittal to the New Jersey Department of Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-02 Shop Drawings

Layout and Detail Drawings
GCL penetration detail drawings

SD-03 Product Data

Manufacturer's Quality Control (QC) Manual
GCL Properties

Manufacturer’s certified raw and roll material data sheets. If needle punching or stitch bonding is used in construction of GCL, the certification shall indicate that the GCL has been continuously inspected for broken needles using an in-line metal detector and all broken needles have been removed. The certified data sheets shall be attested to by a person having legal authority to bind the GCL manufacturing company. Certified test results shall be submitted as least 14 working days prior to delivery of the GCL.

Warranty
Tests, Inspections, and Verifications

Manufacturer’s quality control (QC) manual which describes testing procedures, frequency of testing and acceptance/rejection criteria for QC testing at least 14 days prior to delivery of the GCL.

Qualifications

Manufacturer's qualification statements including resumes of key personnel involved in this project.

SD-04 Samples

Samples

Deliver QC samples at the specified frequencies.

SD-06 Test Reports

Tests, Inspections, and Verifications

SD-07 Certificates

Geosynthetic clay liner

A minimum of 14 days prior to scheduled use, Manufacturer's certificate of compliance stating that the geosynthetic clay liner meets the requirements of this section. The certificate of compliance shall be attested to by a person having legal authority to bind the geosynthetic clay liner Manufacturer.

1.3 QUALIFICATIONS

1.3.1 Manufacturer

Geosynthetic clay liner shall be the product of a GCL Manufacturer who has produced the proposed GCL using the same bentonite, geotextiles, sewing thread, and adhesive for at least 5 completed projects and shall have produced a minimum of 2,000,000 square feet of the proposed GCL. The laboratory shall carry current accreditation via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests the laboratory will be required to perform.

1.4 DELIVERY, STORAGE, AND HANDLING

Delivery, storage, and handling of GCL shall be in accordance with ASTM D5888.

1.4.1 Delivery

Delivery, storage, and handling of GCL shall be in accordance with ASTM D5888. The Engineer shall be present during unloading of the GCL. Rolls shall be packaged in an opaque, waterproof, protective covering and wrapped around a central core. Tears in the packaging shall be repaired to restore a waterproof protective barrier around the GCL. Unloading of rolls from the delivery vehicles shall be done in a manner that prevents damage to the GCL and its packaging.

1.4.2 Storage

Field storage shall be in flat dry areas, above the ground surface where water cannot accumulate and the GCL rolls can be protected from damage. Storage of the rolls on blocks or pallets will not be allowed unless the GCL rolls are fully supported as approved by the Engineer. Stacks of GCL rolls shall be no greater than three high. Rolls shall be covered with a water proof tarpaulin or plastic sheet if stored outdoors.

1.4.3 Handling

During handling, rolls shall not be dragged, lifted by one end, dropped to the ground, or otherwise damaged. A pipe or solid bar of sufficient strength to support the full weight of the roll without significant bending shall be used for all unloading and handling activities. If recommended by

the Manufacturer, a sling handling method utilizing appropriate loading straps may be used.

1.5 DETAIL DRAWINGS

Submit detail drawings, for approval, a minimum of 14 days prior to installation.

PART 2 PRODUCTS

2.1 GCL PROPERTIES

GCL shall be a manufactured product consisting of a sodium montmorillonite clay (bentonite) layer evenly distributed between two geotextiles. GCL shall conform to the property requirements listed in Table 1 and shall be free of tears, holes, or other defects that may affect its serviceability. Encapsulating geotextiles shall be mechanically bonded together using a needle punch or stitch bonding process. Needle punched and stitch bonded GCLs shall be continuously inspected for broken needles using an in-line metal detector and broken needles shall be removed. GCL panels shall be continuously marked with non-toxic waterproof ink 12 inches from both edges. Ink color shall be different from that of the geotextile. The minimum manufactured GCL panel width shall be 13.5 feet and the minimum manufactured GCL panel length shall be 98 feet.

TABLE 1
GCL PROPERTIES

PROPERTY	TEST METHOD	TEST VALUE	CQC TESTING FREQUENCY (MIN)
BENTONITE			
Swell Index Test, minimum	ASTM D5890	24 mL	
Fluid Loss, maximum	ASTM D5891	18 mL	
UPPER GEOTEXTILE PROPERTIES			
Material Type		Woven or Nonwoven	
Mass per Unit Area, min. - Woven or - Nonwoven (2)	 ASTM D5261 ASTM D5261	 3.0 ounces/sq yd 5.9 ounces/sq yd	
LOWER GEOTEXTILE PROPERTIES			
Material Type		Nonwoven	
Mass per Unit Area, min.	ASTM D5261	5.9 ounces/sq yd	
COMPOSITE			
Bentonite Mass/Unit Area, minimum, Note 3	ASTM D5993	0.75 lbs/sq foot	
GCL Mass/Unit Area, minimum, Note 3	ASTM D5993	0.81 lbs/sq foot	per 5000 sq yd
Moisture Content, maximum	ASTM D5993	35 percent	
Tensile Strength, minimum, (MD)	ASTM D6768	23 lbs/in	per 25000 sq yd

TABLE 1
GCL PROPERTIES

PROPERTY	TEST METHOD	TEST VALUE	CQC TESTING FREQUENCY (MIN)
Index Flux, maximum	ASTM D5887	1.0×10^{-6} cubic cm/sec-sq cm	per 30000 sq yd
Peel Strength, MARV MD	ASTM D6496	2.1 lbs/inch	per 5000 sq yd

Note 1: Upper (cap) and lower (carrier) designations refer to the respective orientation during manufacturing and not necessarily to the as-placed orientation.
Note 2: Upper or lower geotextile shall contain a scrim component with mass per unit area greater than 2.9 ounces/square yard for dimensional stability.
Note 3: Bentonite mass/unit area shall be computed at 0 percent moisture content. Bentonite mass/unit area is exclusive of glues added to the bentonite.

2.2 TESTS, INSPECTIONS, AND VERIFICATIONS

2.2.1 Manufacturing Sampling and Testing

GCL and its components shall be sampled and tested in accordance with the Manufacturer's approved QC manual. The Manufacturer's QC procedures shall be in accordance with ASTM D5889. Test results not meeting the requirements specified in Table 1 shall result in the rejection of applicable rolls. The Manufacturer's QC manual shall describe procedures used to determine rejection of applicable rolls. As a minimum, rolls produced immediately prior to and immediately after the failed roll shall be tested for the same failed parameter. Testing shall continue until a minimum of three successive rolls on both sides of the original failing roll pass the failed parameter.

PART 3 EXECUTION

3.1 SAMPLES AND TESTS

3.1.1 Samples

Collect QC samples at approved locations upon delivery to the site at indicated frequencies. Samples shall be collected, packaged, and transported in accordance with ASTM D6072. Samples shall be identified with a waterproof marker by Manufacturer's name, product identification, lot and roll number. The date, a unique sample number, the machine direction, and the top surface of the GCL shall also be noted on the sample. The outer layer of the GCL roll shall be discarded prior to sampling a roll. Samples shall then be collected by cutting the full-width of the GCL sheet a minimum of 3 feet wide in the machine direction. An additional 24 by 24 inch QA sample shall be collected, labeled, and submitted to the Engineer each time QC samples are collected.

3.1.2 Conformance Tests

Provide QC samples to the QC laboratory to determine bentonite mass per unit area (ASTM D5993), peel strength (ASTM D6496), flux (ASTM D5887) and tensile strength (ASTM D6768). Tests not meeting the requirements specified in

Table 1 shall result in the rejection of applicable rolls. Determination of applicable rolls shall be as described in paragraph Tests, Inspections and Verifications.

3.2 INSTALLATION

3.2.1 Subgrade Preparation

The subgrade shall be compacted in accordance with Section 31 23 00 EXCAVATION AND FILL. The subgrade surface shall be smooth and free of vegetation, standing water, and angular stones or other foreign matter that could damage the GCL. At a minimum, the subgrade surface shall be rolled with a smooth-drum compactor of sufficient weight to remove any wheel ruts, footprints, or other abrupt grade changes. All protrusions extending more than 0.5 inches from the subgrade surface (or less if recommended by the Manufacturer) shall either be removed, crushed, or pushed into the surface with the smooth-drum compactor. Each day during placement, the Engineer (or their authorized representative) and installer shall inspect the surface on which GCL is to be placed and the installer shall certify in writing that the surface is acceptable.

3.2.2 Placement

GCL shall be installed as soon as practical after completion and approval of the subgrade. Rolls shall be delivered to the work area in their original packaging. Immediately prior to deployment, the packaging shall be carefully removed without damaging the GCL. GCL which has been hydrated prior to being covered by an overlying geomembrane or a minimum of 12 inches of cover soil shall be removed and replaced. Hydrated GCL is defined as having become soft as determined by squeezing the material with finger pressure or material which has exhibited swelling. If the subgrade is soil, construction equipment may be used to deploy GCL. If the subgrade is a geosynthetic material, GCL shall be deployed by hand or by use of approved light weight equipment with pneumatic tires which will not damage the underlying geosynthetic material. GCL shall not be dragged over the ground surface. Deployed GCL panels shall lie flat on the subgrade surface, with no wrinkles or folds and be in direct contact with the subgrade.

3.2.3 Seams

On side slopes, GCL shall be placed with seams oriented parallel to the line of maximum slope and shall be free of tension or stress upon completion of installation. Panels shall be positioned with the overlap recommended by the Manufacturer, but not less than 6 inches for panel sides or 18 inches for panel ends. Soil or other foreign matter shall be removed from the overlap area immediately prior to seaming. Granular bentonite of the same type as the bentonite used for the GCL shall be placed continuously along the entire overlap width at a minimum rate of 0.25 lbs/linear foot or as recommended by the Manufacturer whichever application rate is greater. Granular bentonite shall not be placed nor permitted to enter the underlying geocomposite drainage layer. Construction adhesive or other approved seaming methods recommended by the Manufacturer shall be used for horizontal seams on slopes. Overlaps which occur on slopes shall be constructed with the up slope GCL shingled over the down slope GCL. Alternate seaming methods may be approved if recommended by the Manufacturer.

3.2.4 GCL Field QA

When deployed, GCL shall be visually inspected for needles and scanned with a hand-held device to verify Manufacturer's quality control for needle removal. Scanning frequency may be reduced if approved by the Engineer. Discontinuous stitches, unraveled stitches, rust spots, and suspect areas shall be inspected for needles. Needles shall be removed and the damaged area repaired.

3.2.5 Protection

Only those GCL panels which can be anchored and covered in the same day shall be unpackaged and installed. If exposed GCL cannot be permanently covered before the end of a working day, it shall be temporarily covered with plastic or other waterproof material to prevent hydration.

3.3 REPAIRS

Holes or tears in GCL shall be repaired by placing a patch of GCL extending a minimum of 12 inches beyond the edges of the hole or tear on all sides. Granular bentonite or bentonite mastic of the same type as the bentonite used for the GCL shall be applied at a minimum rate of 0.25 lbs/linear foot in the overlap area. Patches shall be secured with a construction adhesive or other approved methods as recommended by the Manufacturer.

3.4 PENETRATIONS

Provide watertight seal for penetrations through GCL. Penetration details shall be as indicated and as recommended by the GCL Manufacturer whichever is more stringent subject to Engineer approval. Provide GCL with seams aligned over appurtenance or carefully cut the GCL to be penetrated using a sharp utility knife. For GCL locations not underlain by natural or geocomposite gas venting or drainage layers, 1) provide 3 inch minimum depth notch sloped at 1 horizontal to 1 vertical or flatter completely around appurtenance, and 2) fill notch with granular bentonite to elevation of GCL to form a watertight seal. Provide GCL collar using new GCL extending 24 inches minimum beyond limit of removed, cut and/or damaged GCL. GCL collar shall be in direct contact with penetration; the collar may be cut to improve its fit around the penetration (e.g. "starburst" or "pie" pattern). Provide granular bentonite of the same type as the bentonite used for the GCL continuously along the entire overlap width at a minimum application rate of 0.25 lbs/linear foot or as recommended by the Manufacturer whichever application rate is greater. Secure GCL collar to prevent movement or dislodging during subsequent material placement.

3.5 COVERING

GCL shall not be covered prior to inspection and approval by the Engineer. Cover soil shall be free of angular stones or other foreign matter which could damage the GCL. The maximum particle size of cover soil overlying and in contact with GCL shall be 1 inch. Cover soil shall not be dropped directly onto the GCL from a height greater than 3 feet. The soil shall be pushed out over the GCL in an upward tumbling motion. The direction of backfilling shall proceed in the direction of downgradient shingling of GCL overlaps; except that on side slopes, soil backfill shall be placed from the bottom of the slope upward. Cover soil shall be placed such that soil does not enter the GCL overlap zone and tensile stress are not mobilized in the

GCL. No equipment shall be operated on the top surface of the GCL without permission from the Engineer. The initial loose soil lift thickness shall be 12 inches. Equipment with ground pressures less than 7.0 psi shall be used to place the first lift over the GCL. A minimum of 12 inches of soil shall be maintained between construction equipment with ground pressures greater than 7 psi and the GCL during the covering process. Equipment placing cover soil shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 5 mph. Cover soil compaction and testing requirements are described in Section 31 23 00 EXCAVATION AND FILL.

-- End of Section --

SECTION 31 05 19

GEOTEXTILE

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D4354	(2012) Sampling of Geosynthetics for Testing
ASTM D4491	(2015) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4751	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D4759	(2011) Determining the Specification Conformance of Geosynthetics
ASTM D4873	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe
ASTM D7238	(2017) Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GT13(a)	(2017; Rev4) Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate

1.2 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an “NJDEP” or “EPA” designation require submittal to the New Jersey Department of

Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-03 Product Data

Thread

A minimum of 14 days prior to scheduled use, proposed thread type for sewn seams along with data sheets showing the physical properties of the thread.

Manufacturing Quality Control Sampling and Testing

A minimum of 14 days prior to scheduled use, Manufacturer’s quality control manual.

SD-04 Samples

Quality Assurance Samples and Tests

Samples for quality assurance testing; assign 14 days in the schedule to allow for testing.

SD-06 Test Reports

Sewn seam strength

SD-07 Certificates

Geotextile

A minimum of 14 days prior to scheduled use, Manufacturer’s quality control test results and Manufacturer’s certificate of compliance stating that the geotextile meets the requirements of this section. For needle punched geotextiles, the Manufacturer shall also certify that the geotextile has been continuously inspected using permanent on-line full-width metal detectors and does not contain any needles which could damage other geosynthetic layers. The certificate of compliance shall be attested to by a person having legal authority to bind the geotextile manufacturer.

1.3 DELIVERY, STORAGE, AND HANDLING

Label, deliver, store, and handle geotextile in accordance with ASTM D4873.

1.3.1 Delivery

Notify the Engineer a minimum of 24 hours prior to delivery and unloading of geotextile rolls packaged in an opaque, waterproof, protective plastic wrapping. The plastic wrapping shall not be removed until deployment. If quality assurance samples are collected, immediately rewrap rolls with the plastic wrapping. Geotextile or plastic wrapping damaged during storage or handling shall be repaired or replaced, as directed. Label each roll with the Manufacturer's name, geotextile type, roll number, roll dimensions (length, width, gross weight), and date manufactured.

1.3.2 Storage

Protect rolls of geotextile from construction equipment, chemicals, sparks and flames, temperatures in excess of 160 degrees F, or any other environmental condition that may damage the physical properties of the geotextile. To protect geotextile from becoming saturated, either elevate rolls off the ground or place them on a sacrificial sheet of plastic in an area where water will not accumulate.

1.3.3 Handling

Handle and unload geotextile rolls with load carrying straps, a fork lift with a stinger bar, or an axial bar assembly. Rolls shall not be dragged along the ground, lifted by one end, or dropped to the ground.

1.4 LABORATORY QUALIFICATIONS

Laboratories shall have performed quality control and/or quality assurance testing of the geotextiles for at least five completed projects having a total minimum area of 2 million square feet. The laboratories shall carry current accreditation via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests the laboratory will be required to perform.

PART 2 PRODUCTS

2.1 RAW MATERIALS

2.1.1 Geotextile

Provide geotextile that is a nonwoven (as indicated in Tables 1 and 2) needle punched pervious sheet of polymeric material consisting of long-chain synthetic polymers composed of at least 95 percent by weight polyolefins, polyesters, or polyamides. The use of woven slit film geotextiles (i.e. geotextiles made from yarns of a flat, tape-like character) will not be allowed. Add stabilizers and/or inhibitors to the base polymer, as needed, to make the filaments resistant to deterioration by ultraviolet light, oxidation, and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. Finish the edges of the geotextile to prevent the outer fiber from pulling away from the geotextile. Geotextiles shall meet the requirements specified in Tables 1 and 2. Where applicable, Tables 1 and 2 property values represent minimum average roll values (MARV) in the weakest principal direction. Values for AOS represent maximum average roll value and corresponding 95 percent opening size (O_{95}) represents the maximum average roll values (MaxARV).

TABLE 1
MINIMUM PHYSICAL REQUIREMENTS FOR
6 OZ/SY SEPARATION GEOTEXTILE (4)

PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
Grab Tensile Strength	lbs	158	ASTM D4632

TABLE 1 MINIMUM PHYSICAL REQUIREMENTS FOR 6 OZ/SY SEPARATION GEOTEXTILE (4)			
Elongation Break	percent	≥ 50	ASTM D4632
Sewn Seam Strength	lbs	142	ASTM D4632
CBR Puncture Strength	lbs	320	ASTM D6241
Trapezoid Tear Strength	lbs	56	ASTM D4533
Apparent Opening Size	U.S. sieve	No. 30 (1)	ASTM D4751
Permittivity	sec -1	0.02	ASTM D4491
Ultraviolet Stability	percent	70 at 500 hrs	ASTM D7238

(1) O_{95} not greater than 0.024 inch.
(2) Evaluation to be on 50mm strip tensile specimens after 500 hours exposure.
(3) Minimum MQC testing frequency of 1 test per 40,000 square feet unless otherwise indicated. Minimum MQC testing frequency of one test per material for sewn seam strength, apparent opening size, and permittivity. Ultraviolet stability based on Manufacturer's historical data.
(4) Table 1 values meet GSI GRI GT13(a) Table 1(b) – Geotextile Properties Class 2 (Moderate Survivability).

TABLE 2 MINIMUM PHYSICAL REQUIREMENTS FOR 8 OZ/SY SEPARATION GEOTEXTILE (4)			
PROPERTY	UNITS	ACCEPTABLE VALUES	TEST METHOD
Grab Tensile Strength	lbs	203	ASTM D4632
Elongation Break	percent	≥ 50	ASTM D4632
Sewn Seam Strength	lbs	183	ASTM D4632
CBR Puncture Strength	lbs	440	ASTM D6241

TABLE 2 MINIMUM PHYSICAL REQUIREMENTS FOR 8 OZ/SY SEPARATION GEOTEXTILE (4)			
Trapezoid Tear Strength	lbs	79	ASTM D4533
Apparent Opening Size	U.S. sieve	No. 30 (1)	ASTM D4751
Permittivity	sec -1	0.02	ASTM D4491
Ultraviolet Stability	percent	80 at 500 hrs	ASTM D7238

(1) O_{95} not greater than 0.024 inch.
(2) Evaluation to be on 50mm strip tensile specimens after 500 hours exposure.
(3) Minimum MQC testing frequency of 1 test per 40,000 square feet unless otherwise indicated. Minimum MQC testing frequency of one test per material for sewn seam strength, apparent opening size, and permittivity. Ultraviolet stability based on Manufacturer's historical data.
(4) Table 2 values meet GSI GRI GT13(a) Table 1(a) – Geotextile Properties Class 1 (High Survivability).

2.1.2 Thread

Construct sewn seams with high-strength polyester, nylon, or other approved thread type. Thread shall have ultraviolet light stability equivalent to the geotextile and the color shall contrast with the geotextile.

2.2 MANUFACTURING QUALITY CONTROL SAMPLING AND TESTING

The Manufacturer is responsible for establishing and maintaining a quality control program to assure compliance with the requirements of the specification. Provide documentation describing the quality control program. Perform manufacturing quality control sampling and testing in accordance with the Manufacturer's approved quality control manual. As a minimum, geotextiles shall be randomly sampled for testing in accordance with ASTM D4354, Procedure A. Acceptance of geotextile shall be in accordance with ASTM D4759. Submit MQC test results. Tests not meeting the specified requirements will result in the rejection of applicable rolls.

2.3 CONCRETE SAND

Paragraph "Concrete Sand" of Section 31 23 00.

PART 3 EXECUTION

3.1 QUALITY ASSURANCE SAMPLES AND TESTS

3.1.1 Quality Assurance Samples

Provide assistance to the Engineer in the collection of quality assurance samples for quality assurance testing. Collect samples upon delivery to the

site in accordance with ASTM D4354, Procedure B. Lot size for quality assurance sampling shall be considered to be the shipment quantity of the product or a truckload of the product, whichever is smaller. The unit size shall be considered one roll of geotextile. Identify samples with a waterproof marker by Manufacturer's name, product identification, lot number, roll number, and machine direction. The date and a unique sample number shall also be noted on the sample. Discard the outer layer of the geotextile roll prior to sampling a roll. Samples shall then be collected by cutting the full-width of the geotextile sheet a minimum of 3 feet long in the machine direction. Rolls which are sampled shall be immediately resealed in their protective covering.

3.1.2 Quality Assurance Tests

Provide quality assurance samples to a laboratory independent from the laboratory utilized for Manufacturer’s quality control testing. Geotextile and geotextile seam samples shall be tested to verify that geotextile and geotextile seams meet the requirements specified in Tables 1 and 2. Test method ASTM D7238 shall not be performed on the collected samples. Geotextile product acceptance shall be based on ASTM D4759. Tests not meeting the specified requirements will result in the rejection of applicable roll.

3.2 INSTALLATION

3.2.1 Subgrade Preparation

The surface underlying the geotextile shall be smooth and free of ruts or protrusions which could damage the geotextile. Subgrade materials and compaction requirements shall be in accordance with Section 02 56 13 WASTE CONTAINMENT GEOMEMBRANE and Section 31 23 00 EXCAVATION AND FILL.

3.2.2 Placement

Notify the Engineer a minimum of 24 hours prior to installation of geotextile. Geotextile rolls which are damaged or contain imperfections shall be repaired or replaced as directed. At the time of installation, reject the geotextile if it has defects, rips, holes, deterioration or damage incurred during manufacture, transportation or storage. Geotextile shall be laid flat, smooth, free of tensile stresses, folds, wrinkles, and in direct contact with the subgrade. On slopes steeper than 10 horizontal on 1 vertical, lay the geotextile with the machine direction of the fabric parallel to the slope direction.

3.2.3 Concrete Sand Placement

Paragraph “Concrete Sand Placement” of Section 31 23 00.

3.3 SEAMS

3.3.1 Overlap Seams

Continuously overlap geotextile panels a minimum of 12 inches at all longitudinal and transverse seams unless specified otherwise. Where seams must be oriented across the slope, lap the upper panel over the lower panel. If approved, sewn seams may be used instead of overlapped seams.

3.3.2 Sewn Seams

Sew seams of geotextile with thread of a material meeting the chemical requirements indicated. Seams shall be continuously sewn on all slopes steeper than 1 vertical on 4 horizontal. Sew using “butterfly” seam and 401 two thread locking chain stitch or as recommended by the Manufacturer. For seams that are field sewn, the seams shall be sewn using the same equipment and procedures as will be used for the production seams. Sewn seam strength shall meet the minimum requirements specified in Tables 1 and 2. The minimum distance from the geotextile edge to the stitch line nearest to that edge shall be 3 inches unless otherwise recommended by the Manufacturer. The thread at the end of each seam run shall be tied off to prevent unraveling. Skipped stitches or discontinuities shall be sewn with an extra line of stitching with a minimum of 18 inches of overlap.

3.4 PROTECTION

Protect the geotextile during installation from clogging, tears, and other damage. Damaged geotextile shall be repaired or replaced as directed. Use adequate ballast (e.g. sand bags) to prevent uplift by wind. In no case shall any type of equipment be allowed on the unprotected geotextile. The geotextile shall not be left uncovered for more than 14 days after installation.

3.5 REPAIRS

Repair torn or damaged geotextile. Clogged areas of geotextile shall be removed. Perform repairs by placing a patch of the same type of geotextile over the damaged area. The patch shall extend a minimum of 12 inches beyond the edge of the damaged area. Patches shall be continuously fastened using approved methods. The machine direction of the patch shall be aligned with the machine direction of the geotextile being repaired. Remove and replace geotextile rolls which cannot be repaired.

3.6 PENETRATIONS

Construct engineered penetrations of the geotextile as indicated or by methods recommended by the geotextile manufacturer.

3.7 COVERING

Do not cover geotextile prior to inspection and approval by the Engineer and the QC Inspector. Place cover material in a manner that prevents material from entering the geotextile overlap zone, prevents tensile stress from being mobilized in the geotextile, and prevents wrinkles from folding over onto themselves. On side slopes, backfill shall be placed from the bottom of the slope upward. Soil cover material shall not be dropped onto the geotextile from a height greater than 3 feet. Coarse aggregate cover material shall not be dropped onto the geotextile from a height greater than 1 foot. No equipment shall be operated directly on top of the geotextile without approval of the Engineer. Use equipment with ground pressures less than 7 psi to place the first lift over the geotextile. A minimum of 12 inches of material shall be maintained between full-scale construction equipment and the geotextile. Equipment placing cover material shall not stop abruptly, make sharp turns, spin their wheels, or travel at speeds exceeding 5 mph.

-- End of Section --

SECTION 31 05 20

GEOSYNTHETIC DRAINAGE LAYER

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D1505	(2010) Density of Plastics by the Density-Gradient Technique
ASTM D1603	(2014) Carbon Black Content in Olefin Plastics
ASTM D4218	(2015) Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
ASTM D4355	(2014) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D4491	(2015) Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D4533	(2015) Standard Test Method for Trapezoid Tearing Strength of Geotextiles
ASTM D4632	(2015a) Grab Breaking Load and Elongation of Geotextiles
ASTM D4716	(2008; R 2013) Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
ASTM D4751	(2016) Standard Test Method for Determining Apparent Opening Size of a Geotextile
ASTM D5035	(2011) Breaking Force and Elongation of Textile Fabrics (Strip Method)
ASTM D5199	(2012) Measuring Nominal Thickness of Geosynthetics
ASTM D5261	(2010) Measuring Mass Per Unit Area of Geotextiles

ASTM D6241	(2014) Standard Test Method for the Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe
ASTM D7005	(2003; R 2008) Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites

1.2 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an “NJDEP” or “EPA” designation require submittal to the New Jersey Department of Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-03 Product Data

Sampling and Testing

Manufacturer’s quality control manual

Construction Quality Control (QC) Laboratory

Qualifications of laboratory.

SD-04 Samples

Geocomposite Drainage Layer
Seams and Overlaps

One properly identified 24 by 24 inch minimum size geocomposite drainage layer sample for each material indicated; fasteners proposed for use; and the method of seaming and overlapping.

SD-06 Test Reports

Sampling and Testing

Construction quality control test results.
Geocomposite Drainage Layer

Manufacturer’s quality control test results.

SD-07 Certificates

Geocomposite Drainage Layer

A minimum of 14 days to scheduled use, Manufacturer’s certificate of compliance stating that the geocomposite drainage layer meets the requirements of this section. The certificate of compliance shall be attested to by a person having legal authority to bind the geocomposite drainage layer Manufacturer.

1.3 QUALITY ASSURANCE

Quality control (QC) laboratory shall have provided QC and quality assurance (QA) testing, if required, of geocomposite drainage layers for at least five completed projects, having a total minimum area of 2 million square feet. The laboratory shall carry current accreditation via the Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP) for the tests it will be required to perform.

1.4 DELIVERY, STORAGE, AND HANDLING

The QC inspector shall be present during delivery and unloading of the geocomposite drainage layer. Ensure the geocomposite drainage layer material has not been damaged during shipping, storage, or handling. Any geocomposite drainage layer material found to be damaged shall be repaired or replaced. Accept delivery of material only after the required submittals have been approved. Each roll shall be labeled with the Manufacturer's name, product identification, lot number, roll number, and roll dimensions. Rolls that have attached geotextiles shall be individually wrapped in plastic. Store the rolls in a level and dry area.

Geocomposite drainage material shall be protected from becoming saturated. Rolls shall either be elevated off the ground or placed on a sacrificial sheet of plastic. Geocomposite drainage layer rolls or sheets shall be protected from dust, dirt, construction equipment, ultraviolent radiation, chemicals, sparks and flames, temperatures in excess of 160 degrees F, and any other environmental conditions that may damage the physical properties of the geocomposite drainage layer.

Geocomposite drainage layer rolls or sheets shall be handled and unloaded with load carrying straps, a fork lift with stinger bar, or an axle bar assembly. Rolls shall not be dragged along the round, lifted by one end, or dropped to the ground.

PART 2 PRODUCTS

2.1 GEOCOMPOSITE DRAINAGE LAYER

The polymer used to manufacture the geonet component of the geocomposite drainage layer shall be polyethylene which is clean and free of any foreign contaminants. Submit one properly identified 24 by 24 inch minimum size geocomposite drainage layer sample; fasteners proposed for use; and the method of seaming and overlapping. Submit Manufacturer's quality control test results. Regrind material which consists of edge trimmings and other scraps may be used to manufacture the geonet; however, post-consumer recycled materials shall not be used. Geocomposite drainage layer shall meet the property requirements listed in Table 1. The geonet shall be covered on one or both sides as indicated with nonwoven needle-punched geotextile. Create geocomposite by heat bonding geotextile to the geonet. The geotextile shall not be bonded to the drainage net within 6 inches of the edges of the rolls or sheets. Where applicable, Table 1 property values represent minimum average roll values (MARV). The value for AOS represents the maximum average roll value (MaxARV).

TABLE 1 GEOCOMPOSITE DRAINAGE LAYER PROPERTIES			
PROPERTY	TEST METHOD	TEST VALUE	MINIMUM MQC TESTING FREQUENCY
GEONET COMPONENT			
Thickness, minimum avg, Note 1	ASTM D5199	200 mil	100,000 sq ft
Polymer Density, minimum avg	ASTM D1505	0.940 g/cc	Note 6
Carbon Black Content	ASTM D1603 ASTM D4218	1-3 percent	100,000 sq ft
Tensile Strength, minimum avg, Note 2	ASTM D5035	45 lbs/inch	100,000 sq ft
GEOTEXTILE COMPONENT			
Mass/Unit Area, MARV	ASTM D5261	6.0 oz/sy	100,000 sq ft
Grab Strength, MARV	ASTM D4632	157 lbs	100,000 sq ft
Grab Elongation, MARV	ASTM D4632	50 percent	100,000 sq ft
Trapezoid Tear Strength, MARV	ASTM D4533	55 lbs	100,000 sq ft
CBR Puncture Strength	ASTM D6241	320 lbs	100,000 sq ft
Permittivity, MARV	ASTM D4491	0.2/sec	500,000 sq ft
AOS(O95), MaxARV	ASTM D4751	0.25 mm	500,000 sq ft
UV Stability, percent retained (500 hours)	ASTM D4355	70 percent	Note 3
GEOCOMPOSITE			
Transmissivity, min, including attached geotextiles, Note 4	ASTM D4716	- 4.8 gal/min-foot (single sided) - 0.5 gal/min-foot (double-sided) Note 7	200,000 sq ft
Geonet/Geotextile Adhesion, minimum avg, Note 5	ASTM D7005	0.5 lbs/inch	100,000 sq ft
Note 1: The diameter of the presser foot shall be 2.22 inches and the pressure shall be 2.9 psi. For other thickness options, see Manufacturer's literature.			
Note 2: Average peak value for five equally spaced machine direction tests across the roll width.			
Note 3: Manufacturer's historical data.			
Note 4: For single and double sided geocomposite drainage layer, measure manufacturing quality control transmissivity tests using gradient of 0.1 under a minimum normal pressure of 10,000 psf. Use a minimum seating period of 15 minutes. Perform the test between rigid end platens.			
Note 5: Average of five tests across the roll width. Discounting the outer 1 foot of each side of the roll, collect samples at the 10, 30, 50, 70, and 90 percent positions across the roll width. Test both sides for double sided geocomposites.			

TABLE 1 GEOCOMPOSITE DRAINAGE LAYER PROPERTIES			
PROPERTY	TEST METHOD	TEST VALUE	MINIMUM MQC TESTING FREQUENCY
Note 6: Once per project.			

2.2 SAMPLING AND TESTING

2.2.1 Manufacturing Quality Control Testing

Manufacturing quality control test methods and frequencies shall be in accordance with Table 1 unless otherwise approved. Submit Manufacturer's quality control manual and construction quality control test results.

PART 3 EXECUTION

3.1 INSTALLATION

3.1.1 Surface Preparation

Prior to placement of the geocomposite drainage layer, the subgrade shall be smooth and free of all materials which could damage the geocomposite drainage layer.

3.1.2 Placement

The geocomposite drainage layer shall not be damaged during placement. Unroll the drainage layer in the direction of maximum slope, keeping the net flat against the subgrade to minimize wrinkles and folds. The geocomposite drainage layer shall not be dragged across textured geomembrane if a geotextile is attached to the surface facing the geomembrane. During placement of geocomposite, care shall be taken not to entrap dirt or dust in the geotextile or geonet that could cause clogging of the system. Dirt or dust entrapped shall be washed clean with water prior to placement of the next material on top of it. Place adequate ballast (e.g. sandbags) to prevent uplift by wind prior to covering. Care should be taken with the handling of sandbags to prevent rupture or damage of the sandbags.

3.1.3 Seams and Overlaps

3.1.3.1 Geonet Side Seams

Overlap geonet side seams a minimum of 4 inches. Side seam fastener spacing shall be a maximum of 5 feet. In anchor trenches, fastener spacing shall be a maximum of 1 foot.

3.1.3.2 Geonet End Seams

Overlap geonet end seams a minimum of 1 foot. End seam fastener spacing shall be a maximum of 1 foot. The overlaps shall be in the direction of flow. End seams shall not be allowed on side slopes steeper than 4 horizontal on 1 vertical.

3.1.3.3 Geonet Fasteners

Tie geonet rolls together with plastic fasteners. The fasteners shall be a contrasting color from the geonet and attached geotextiles. Metallic fasteners will not be allowed.

3.1.3.4 Geotextile Seams

The bottom layers of geotextile shall be overlapped. The top layer of geotextile shall be continuously sewn in accordance with Section 31 05 19 GEOTEXTILE. Geotextile shall be overlapped a minimum of 4 inches prior to sewing.

3.1.3.5 Geotextile Cap Strips

Place geotextile cap strips over any exposed edges of geocomposite. Cap strips shall be a minimum of 2 feet in width and shall be thermally bonded to the geotextile component of the geocomposite by methods that do not damage the geotextile.

3.1.4 Stacked Geocomposite Drainage Layers

When geocomposite drainage layers are to be stacked, stagger roll ends and edges so that joints do not lie above one another. Stacked layers shall be laid in the same direction and in a manner that prevents interlocking.

3.1.5 Penetrations

Submit penetration details. Mechanically attach a geotextile apron to pipes and other appurtenances penetrating through the geocomposite drainage layer so that soil is prevented from getting into the geocomposite drainage layer. The apron of the attached geotextile shall extend out from the pipe or appurtenance a minimum of 2 feet. The apron geotextile shall be thermally bonded to the geotextile.

3.2 REPAIRS

3.2.1 Geonet Damage

Make repairs by placing a patch of the geocomposite drainage layer over the damaged area. Extend the patch a minimum of 2 feet beyond the edge of the damage. Use approved fasteners, spaced every 6 inches around the patch, to hold the patch in place. If more than 25 percent of the roll width is damaged, approval must be obtained to repair or replace the damaged roll.

3.2.2 Geotextile Damage

Repair damaged geotextile by placing a patch of geotextile over the damaged area with a minimum of 12 inches of overlap in all directions. The geotextile patch shall be sewn or thermally bonded in place by methods that do not damage the geotextile.

3.3 PROTECTION AND BACKFILLING

Cover the geocomposite drainage layer with the specified materials within 14 days of acceptance. The QC Inspector shall be present during covering of

the geocomposite drainage layer. Cover materials shall be placed in accordance with Section 31 23 00.00 20 EXCAVATION AND FILL.

-- End of Section --

SECTION 31 21 00

PIPING; OFF-GAS

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C920	(2014a) Standard Specification for Elastomeric Joint Sealants
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D1693	(2015) Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics
ASTM D2513	(2014; E 2014) Thermoplastic Gas Pressure Pipe, Tubing, and Fittings
ASTM D2774	(2012) Underground Installation of Thermoplastic Pressure Piping
ASTM D3035	(2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM D3261	(2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
ASTM D3892	(1993; R 2009) Packaging/Packing of Plastics
ASTM F1055	(2016) Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing
ASTM F2620	(2016) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

NEW JERSEY DEPARTMENT OF TRANSPORTATION (NJDOT)

NJDOT SHS	(2007) Updated Standard Specifications for Road and Bridge Construction

1.2 SYSTEM DESCRIPTION

The off-gas piping system shall consist of buried and above ground pipe.

1.3 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an “NJDEP” or “EPA” designation require submittal to the New Jersey Department of Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-02 Shop Drawings

Off-Gas Piping System

SD-03 Product Data

Materials and Equipment

1.4 DELIVERY, STORAGE, AND HANDLING

1.4.1 Packaging

Plastic pipe shall be packed, packaged and marked in accordance with ASTM D3892.

1.4.2 Storage

Store materials with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) damage, or other damage. Pipe and fittings shall be handled and stored in accordance with the Manufacturer's recommendations. Piping bundles shall be stored on a prepared surface and should not be stacked more than two bundles high.

PART 2 PRODUCTS

2.1 MATERIALS AND EQUIPMENT

Provide materials and equipment that are new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. Piping material and appurtenances shall be as indicated and shall be suitable for the service intended. Submit Manufacturer's descriptive data and technical literature for each type of pipe, including pressure and temperature ratings, dimensions, type, grade and strength of pipe and fittings, thermal characteristics (coefficient of expansion and thermal conductivity) and chemical resistance. Manufacturer's recommended installation procedures including materials preparation and installation.

2.1.1 Identification

Each piece of pipe shall bear the ASTM designation and the ASTM markings required for that designation.

2.2 POLYETHYLENE (PE) PIPING

Design and fabrication of below grade components of the off-gas piping system shall be in accordance with ASTM D2513 except as modified herein.

2.2.1 PE Pipe

Pipe shall be in accordance with ASTM D3035, Schedule 80, size as indicated. Melt flow shall be less than 1.5 g/10 min. with method ASTM D1248, Condition F. Environmental stress crack resistance shall exceed 1000 hours, ASTM D1693, Condition C.

2.2.2 PE Joints and Fittings

Fittings shall be pressure rated electrofusion fittings in accordance with ASTM F1055 or butt heat fusion fittings in accordance with ASTM D3261.

2.2.3 Pipe Perforations

Water inlet area shall be a minimum of 0.5 square inches per lineal foot. Manufacturer’s standard perforated pipe which essentially meets these requirements may be substituted with prior approval of Engineer.

2.2.3.1 Circular Perforations

Circular holes shall be cleanly cut not more than 1/2 inch or less than 3/16 inch in diameter and arranged in rows parallel to the longitudinal axis of the pipe. Perforations shall be approximately 3 inches center-to-center along rows. The rows shall be approximately 1-1/2 inches apart and arranged in a staggered pattern so that all perforations lie at the midpoint between perforations in adjacent rows.

2.2.3.2 Slotted Perforations

Circumferential slots shall be cleanly cut so as not to restrict the inflow of fluid and uniformly spaced along the length and circumference of the pipe. Width of slots shall not exceed 1/2 inch nor be less than 1/32 inch. The length of individual slots shall not exceed 1-1/4 inches on 3 inch dimeter pipe, or 10 percent of the pipe inside nominal circumference on 4 to 8 inch diameter pipe. Rows of slots shall be symmetrically spaced so that they are fully contained in 2 quadrants of the pipe.

2.3 FILTER MATERIAL

NJDOT SHS, Section 901.03 Coarse Aggregate, Table 901.03-1, Coarse Aggregate No. 67 for gradation and NJDOT SHS, Section 901.03.01 Broken Stone for quality.

2.4 SEALANTS

Sealants shall conform to ASTM C920 Type S, Grade NS, Class 50, Use NT, G, A and O.

PART 3 EXECUTION

3.1 INSTALLING PIPE UNDERGROUND

Installation shall be as specified in Section 31 00 00 EARTHWORK, except as modified herein; and as required by ASTM D2774 for polyethylene pipe.

3.2 INSTALLING PIPE ABOVEGROUND

Install vertical pipe plumb in all directions. Piping shall be secured in position by approved methods when piping is to stand free, or when no structural element is available for providing stability during construction. Temporary caps or plugs shall be provided at pipe openings at the end of each day’s work.

3.3 JOINING PIPE

Butt fusion in accordance with ASTM F2620.

-- End of Section --

SECTION 31 23 00

EXCAVATION AND FILL

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C136	(2014) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	(2015) Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150	(2016) Standard Specification for Portland Cement
ASTM C33	(2016) Standard Specification for Concrete Aggregates
ASTM C39	(2016) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D2216	(2010) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D2487	(2017) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2488	(2017) Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)
ASTM D2937	(2017) Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D422	(1963; R 2007; E 2014; E 2014; withdrawn 2016) Standard Test Method for Particle-Size Analysis of Soils

ASTM D4253	(2016) Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2016) Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D4318	(2017) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4643	(2008) Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating
ASTM D4944	(2011) Standard Test Method for Field Determination of Water (Moisture) Content of Soil by Calcium Carbide Gas Pressure Test
ASTM D4959	(2016) Standard Test Method for Determination of Water Content of Soil By Direct Heating
ASTM D5084	(2016a) Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D6938	(2017) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION (NJDEP)

NJDEP FMG	(2015 Version 3.0) Fill Material Guidance for SRP Sites, Site Remediation Program

NEW JERSEY DEPARTMENT OF TRANSPORTATION (NJDOT)

NJDOT SHS	(2007) Updated Standard Specifications for Road and Bridge Construction

1.2 DEFINITIONS

1.2.1 Degree of Compaction

Degree of compaction is expressed as a percentage of the maximum dry density obtained by the test procedure presented in ASTM D698, for general soil types, abbreviated as “percent laboratory maximum density”, unless otherwise indicated. Since ASTM D698 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with ASTM D698 and corrected with ASTM D4718.

1.2.2 Coverage

Coverage, C, as used herein:

$C = (A_f / A_d) \times N \times 100$ percent

where

N = number of passes of the approved compaction equipment over a given point;

A_f = sum of the end contact areas of the feet on the drums of the compaction equipment; and,

A_d = average surface area of the drum itself based on the average of the diameter over feet and diameter over drum.

Note that the coverage provided by a one-directional pass of a steel wheeled roller with full width front and rear drums is 200 percent. The coverage provided by a one-directional pass of a tracked piece of equipment is 100 percent.

1.3 QUALIFICATIONS

Geotechnical material testing by a commercial testing laboratory or Contractor's validated testing facility for all appropriate fields of testing. Submit qualifications of the commercial testing laboratory or Contractor's validated testing facilities. If Contractor elects to establish testing facilities, do not permit work requiring testing until Contractor's facilities have been inspected, validated and approved by the Engineer.

Environmental laboratory approved by one of the four third-party Accrediting Bodies and shall also hold current National Environmental Laboratory Accreditation Conference (NELAC) accreditation for all appropriate fields of testing. Submit qualifications of the environmental laboratory including quality systems manual.

1.4 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an "NJDEP" or "EPA" designation require submittal to the New Jersey Department of Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-01 Preconstruction Submittals

Work Plan
Submit a minimum of 15 calender days prior to starting work.

Schedule of Activities

Requirements for off-site soil

Compaction equipment

SD-03 Product Data

Commercial Testing Laboratory
Environmental Laboratory

SD-06 Test Reports

Borrow Site Testing

Fill and backfill test

Select material test

Density tests

Moisture Content Tests

Copies of all laboratory and field test reports within 24 hours of the completion of the test.

1.5 DELIVERY, STORAGE, AND HANDLING

Perform in a manner to prevent contamination or segregation of materials.

1.6 WORK PLAN

Submit a Work Plan within 30 calendar days after notice to proceed. No work at the site, with the exception of site inspections and surveys, shall be performed until the Work Plan is approved. Allow 14 calendar days in the schedule for Engineer's review. No adjustment for time or money will be made if resubmittals of the Work Plan are required due to deficiencies in the plan. At a minimum, the Work Plan shall include the following items:

a. Schedule of activities.

b. Equipment to be used, including make, model, and data sheets.

c. Key personnel names, qualifications, and training certifications.

d. Method of excavation, grading, and compaction.

e. Method of run-off control.

f. Dewatering plan for impounded water, water resulting from excavations, and water from regraded material.

g. Method(s) of conditioning or otherwise stabilizing unsuitable materials to a suitable condition. Preference shall be given to moisture conditioning via mechanically turning the material with reliance on environmental factors (i.e. sunlight, wind, and temperature) to reduce the moisture content of the material to suitable levels. Provide contingency methodologies including, but not limited to, addition of stabilization agents such as Portland cement or kiln dust.

h. Borrow sources, haul routes, and stockpile location(s).

i. Geosynthetic materials installation and protection methods.

j. Decontamination procedures.

k. Spill contingency plan.

l. Site restoration plan.

1.6.1 Schedule of Activities

Submit Schedule of Activities for the entire project that is a forward planning as well as a project monitoring tool. Contractor management personnel must actively participate in its development. Indicate the proposed sequence to perform the work and dates contemplated for starting and completing all schedule activities. Provide in Gantt format using the Critical Path Method (CPM) of network calculation and precedence diagrams. Develop the Project Schedule to the appropriate level of detail to address major milestones and to allow for satisfactory project planning and execution. Provide updated Schedule of Activities on a biweekly frequency.

1.7 REQUIREMENTS FOR OFF SITE SOIL

Off site soil in accordance with NJDEP FMG requirements.

Contractor shall provide Engineer open access to the off site soil and aggregate source(s) for the purposes of inspection and obtaining samples for quality assurance testing.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

2.1.1 Satisfactory Materials

ASTM D2487 group symbol GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML, CH, and MH free of debris, roots, wood, scrap material, vegetation, refuse, soft unsound particles, and frozen, deleterious, or objectionable materials. Unless otherwise indicated, the maximum particle diameter shall be one-half the lift thickness at the intended location.

2.1.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials. Unsatisfactory materials also include man-made fills, trash, refuse, or backfills from previous construction. Unsatisfactory material also includes material classified as satisfactory which contains root and other organic matter, frozen material, and stones larger than 3 inches.

2.1.3 Common Fill

ASTM D2487, group symbol GW, GP, GM, GC, SW, SP, SM, and SC, maximum 50 percent by weight passing ASTM D1140, No. 200 sieve, and maximum particle size of 1 inch.

2.1.4 Landfarm Material

Material resulting from excavation and regrading of soil material located within North Landfarm limits.

2.1.5 Select Landfarm Material

Material resulting from excavation and regrading of soil material located within North Landfarm limits and southeast and southwest dikes of North Landfarm with maximum particle size of 1 inch.

2.1.6 AOC-1 Related Material

Soil and non-soil material located outside of North Landfarm limits related to operation of, or migration from, AOC-1 North Landfarm. Non-soil material shall have a maximum particle size of 2 inches. Material may be excavated and consolidated within North Landfarm limits beneath the cap system subject to Engineer approval.

2.2 COARSE AGGREGATE

Natural, durable, competent material meeting NJDOT SHS, Section 901.03 Coarse Aggregate, Table 901.03-1, Coarse Aggregate for gradation and NJDOT SHS, Section 901.03.01 Broken Stone for quality. Gradation as indicated.

2.3 CONCRETE SAND

Natural or manufactured, durable, competent material meeting NJDOT SHS, Sections 901.06 and 901.06.02 and Tables 901.06.02-1 and 901.06.02-2.

2.4 CLAY MATERIAL

Free of roots, debris, organic or frozen material, and shall have a maximum clod size of 2 inches at time of compaction.

TABLE 1
PHYSICAL PROPERTIES OF CLAY

PROPERTY	UNITS	ACCEPTABLE VALUE	TEST METHOD
Particle size, max	inches	1	ASTM D422
Percent passing No. 4 sieve, min	percent	80	ASTM D422
Percent passing No. 200 sieve, min	percent	50	ASTM D1140
Liquid limit, min	percent	35	ASTM D4318
Plasticity index, min	percent	10	ASTM D4318
Plasticity index, max	percent	40	ASTM D4318

PART 3 EXECUTION

3.1 PROTECTION

3.1.1 Drainage and Dewatering

Provide for the containment, collection, conveyance, treatment, sampling and testing as required, and discharge of surface and subsurface water encountered within the North Landfarm limits during construction.

3.1.1.1 Drainage

So that construction operations progress successfully, completely drain construction site during periods of construction to keep materials

sufficiently dry. Establish/construct storm drainage features at the earliest stages of construction, and throughout construction grade the surrounding construction area to provide positive surface water runoff away from the construction activity. Contain water within the North Landfarm limits using temporary ditches, dikes, swales, and other drainage features and equipment as required. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material. Moisture condition or otherwise stabilize removed unsuitable material and place within North Landfarm limits beneath the cap system. Excavation shall be performed so that the site, the area immediately surrounding the site, and the area affecting operations at the site shall be continually and effectively drained.

3.1.1.2 Dewatering

Dewatering shall be limited to that necessary to assure adequate access, a safe excavation, safely facilitate sampling, and ensure that compaction requirements can be met.

Groundwater flowing toward or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Control measures shall be implemented by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least one foot below the working level unless otherwise approved by Engineer.

Dewatering liquid shall be managed on-site as directed by Earth Systems and in accordance with applicable permits and regulations.

3.1.2 Underground Utilities

Physically verify the location and elevation of existing utilities prior to starting construction. Scan the construction site with electromagnetic and sonic equipment and mark the surface of the ground where existing underground utilities are discovered. Excavation made with power-driven equipment is not permitted within two feet of known utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand or using the air/vacuum extraction technique. Start hand excavation or air/vacuum extraction on each side of the indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the excavation until approval for backfill is granted by Engineer.

3.1.3 Machinery and Equipment

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Report damage to utility lines or subsurface construction immediately to the Engineer. Repair, or remove and provide new pipe for existing or newly installed pipe that has been displaced or damaged.

3.2 EXCAVATION

Excavate to contours, elevation, and dimensions indicated. Reuse excavated materials that meet the specified requirements for the material type required at the intended location. Excavate soil disturbed or weakened by Contractor's operations, soils softened or made unsuitable for subsequent construction due to exposure to weather. Excavations below indicated depths will not be permitted except to remove unsatisfactory material. Remove unsatisfactory material encountered below the indicated grades as directed by Engineer and replace with suitable material. If located outside of North Landfarm limits and within AST 7945 secondary containment dike refill excavation with materials the same as the excavated material(s) as directed by the Engineer and compact to minimum 90 percent laboratory maximum density or to provide a firm, stable, and nonyielding surface. Existing material(s) are unknown and may consist of a coarse aggregate surface layer underlain by Common Fill-like or low permeability cohesive soil (i.e. Clay Material). If located within North Landfarm limits refill with 1) removed material after removed material is moisture conditioned or otherwise stabilized and compact to provide a firm, stable, and nonyielding surface, 2) Common Fill compacted to minimum 90 percent laboratory maximum density or to provide a firm, stable, and nonyielding surface as directed by the Engineer, 3) North Landfarm Material compacted to provide a firm, stable, and nonyielding surface, or 4) North Landfarm southeast or southwest dike material compacted to provide a firm, stable, and nonyielding surface.

Satisfactory material removed below the depths indicated, without specific direction of the Engineer, shall be replaced with satisfactory materials to the indicated excavation grade.

3.3 SUBGRADE PREPARATION

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials in accordance with paragraph “Excavation” and as directed by the Engineer. The surface shall be scarified to a depth of 6 inches before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 6 inches, pulverized, and compacted to the specified density or to a firm, stable, and nonyielding surface as directed by the Engineer. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 12 inches and compacted as specified for the adjacent fill. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. Compaction shall be accomplished by padfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved compaction equipment well suited to the material being compacted. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used.

3.3.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall) which would promote degradation of an otherwise acceptable subgrade. After stripping, clearing, and grubbing or excavation, proof roll the exposed subgrade with 400 percent coverage of

a minimum 40,000 pound tracked piece of equipment with a minimum ground pressure of 7.0 psi, six one-directional passes of a dump truck loaded with 12 cubic feet of soil, or minimum 400 percent coverage with a 15 ton, pneumatic-tired roller. Operate the equipment in a systematic manner to ensure the number of passes over all areas, and at speeds between 2 1/2 to 3 1/2 miles per hour. When proof rolling, one-half of the coverage made with the roller shall be in a direction perpendicular to the other coverages. Notify the Engineer a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Engineer. Undercut rutting or pumping as directed by the Engineer to a depth of 12 inches and replace with material and compact in accordance with paragraph “Excavation”.

3.4 GRADING AREAS

Divide work into grading areas within which regraded material will be placed in embankments, fills, and required backfills. Maintain stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber tired equipment or provision of a temporary plastic cover, the ground surface at stockpile locations; separately stockpile regraded North Landfarm materials from imported materials. Protect stockpiles of imported materials from contamination that may destroy the quality and fitness of the imported material.

3.5 FILLING AND BACKFILLING

Fill and backfill to contours, elevations, and dimensions indicated. Compact each lift before placing overlaying lift.

Number and account for, at the end of each shift, grade stakes if utilized to monitor lift thickness of layers underlying geosynthetic materials (i.e., Common Fill or Select Landfarm Material layer underlying geosynthetic cap barrier layers). Grade stakes shall not be utilized to monitor thickness of layers overlaying geosynthetic materials (i.e., Common Fill overlaying geosynthetic cap barrier layers). When removing grade stakes, no broken portion of the grade stake shall be left in the Common Fill or Select Landfarm Material layer.

3.5.1 Landfarm, Select Landfarm and AOC-1 Related Material Placement

Place in 8 inch loose lifts. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Finish to a smooth surface by blading, rolling with a smooth roller, or both.

3.5.2 Common Fill Placement

Place in 8 inch loose lifts. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Finish to a smooth surface by blading, rolling with a smooth roller, or both.

3.5.3 Coarse Aggregate Placement

Place in 6 inch loose lifts. Backfill adjacent to structures shall be placed as structural elements are completed and accepted.

3.5.4 Concrete Sand Placement

As indicated. Establish general appearance of minimum application rate over test area at beginning of project and visually monitor subsequent areas throughout installation for conformity to approved test area. Quantitatively assess concrete sand application rate by dividing the recorded total weight of concrete sand applied by the total application area.

3.5.5 Clay Material Placement

Place in 8 inch loose lifts unless otherwise indicated. Place in 6 inch loose lifts when hand operated equipment is used. Compact areas not accessible to rollers or compactors with mechanical hand tampers. Material shall be moistened or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction with the equipment used. Compaction shall be accomplished by padfoot rollers, pneumatic-tired rollers or other approved compaction equipment well suited to the material being compacted.

3.6 COMPACTION

3.6.1 General Site

Compact underneath areas designated for vegetation and areas outside the 5 foot line of the paved area or structure to minimum 90 percent laboratory maximum density.

3.6.2 Structures, Spread Footings, and Concrete Slabs

Compact top 12 inches of subgrades within 5 feet line of and beneath paved area or structure to minimum 95 percent laboratory maximum density. Compact Common Fill to minimum 95 percent laboratory maximum density.

3.6.3 Adjacent Area

Compact areas within 5 feet of and beneath structures to minimum 95 percent laboratory maximum density.

3.6.4 Paved Areas

Compact top 12 inches of subgrades to minimum 95 percent laboratory maximum density. Compact fill and backfill materials to minimum 95 percent laboratory density or minimum 70 percent of ASTM D4253 and ASTM D4254 relative density.

3.6.5 Landfarm, Select Landfarm, and AOC-1 Related Materials Compaction

Compact with minimum of 400 percent coverage using Engineer approved compaction equipment to provide a firm, stable, and unyielding surface, subject to Engineer approval.

3.6.6 Common Fill Compaction

Minimum 90 percent laboratory maximum density unless otherwise indicated.

3.6.7 Clay Material Compaction

Minimum 90 percent laboratory maximum density unless otherwise indicated.

3.7 FINISH OPERATIONS

3.7.1 Grading

Finish grades as indicated within one-tenth of one foot. Grade areas to drain water away from structures. Maintain areas free of trash and debris. For existing grades that will remain but which were disturbed by Contractor's operations, grade as directed.

3.7.2 Protection of Surfaces

Protect newly backfilled, graded, and topsoiled areas from traffic, erosion, and settlements that may occur. Repair or reestablish damaged grades, elevations, or slopes.

3.8 FIELD QUALITY CONTROL

3.8.1 Sampling

Take the number and size of samples required to perform the following tests.

3.8.2 Testing

Perform one of each of the following tests for each material used. Provide additional tests for each source change.

3.8.2.1 Common Fill and Clay Material Testing

Test material in accordance with ASTM C136, ASTM D422, and ASTM D4318 for conformance to ASTM D2487; ASTM D4318 for liquid limit and for plastic limit; ASTM D698 for moisture density relations or ASTM D4253 and ASTM D4254, as applicable. One test per 10,000 cubic yards stockpiled or in-place source material, for changes in material consistency, or minimum of one test per source, whichever is greater.

3.8.2.2 Common Fill and Clay Material Density Tests

Test density in accordance with ASTM D1556, ASTM D2937 or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556 or ASTM D2937 density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556 or ASTM D2937 density test at the start of the job, and for every 20 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations every 10,000 square feet.

Test density of first lift of Common Fill placed above geosynthetic materials in accordance with ASTM D1556 or ASTM D2937 at randomly selected locations every 10,000 square feet. ASTM D6938 density testing of first

lift of Common Fill placed above geosynthetic material shall not be performed so as not to puncture the underlying geosynthetic materials.

3.8.2.3 Common Fill and Clay Material Moisture Content Tests

Test moisture content in accordance with ASTM D6938, ASTM D4643, ASTM D4944, ASTM D4959, or ASTM D2216 whenever a density test is performed. When other than ASTM D2216 moisture tests are used, verify moisture test results by performing an ASTM D2216 moisture test at a location already tested by other methods and at a frequency of one ASTM D6938 test for every 20 non-ASTM D6938 moisture tests.

3.8.2.4 Landfarm, Select Landfarm and AOC-1 Related Material Testing

ASTM D2488 visual-manual classification.

3.8.2.5 Landfarm, Select Landfarm and AOC-1 Related Density Testing

North Landfarm, southeast and southwest North Landfarm dike material, Select North Landfarm, and AOC-1 related materials shall be compacted to provide a firm, stable, and nonyielding surface as determined by the Engineer. Materials that are not firm and stable, yield, or otherwise demonstrate instability shall be excavated and mixed with satisfactory material to create a stable mixture subject to Engineer approval.

Test Landfarm, southeast and southwest North Landfarm dike material, Select Landfarm and AOC-1 related material density *for informational purposes only* if directed by Engineer with Engineer’s determination based on material shearing strength and compressibility during compaction, workability, and particle size distribution. Test in accordance with ASTM D1556, or ASTM D2937 or ASTM D6938. When ASTM D6938 density tests are used, verify density test results by performing an ASTM D1556 or ASTM D2937 density test at a location already ASTM D6938 tested as specified herein. Perform an ASTM D1556 or ASTM D2937 density test at the start of the job, and for every 20 ASTM D6938 density tests thereafter. Test each lift at randomly selected locations every 10,000 square feet. Include density test results in daily field activity report.

3.8.2.6 Landfarm, Select Landfarm and AOC-1 Related Moisture Testing

Test Landfarm, southeast and southwest North Landfarm dike material, Select Landfarm and AOC-1 related material moisture *for informational purposes only* if directed by Engineer with Engineer’s determination based on material shearing strength and compressibility during compaction, workability, and particle size distribution. Test in accordance with ASTM D6938, ASTM D4643, ASTM D4944, ASTM D4959, or ASTM D2216 whenever a density test is performed. When other than ASTM D2216 moisture tests are used, verify moisture test results by performing an ASTM D2216 moisture test at a location already tested by other methods and at a frequency of one ASTM D6938 test for every 20 non-ASTM D6938 moisture tests.

3.8.2.7 Coarse Aggregate Material Testing

Demonstrate conformance with material specification requirements by one of the following:

a. provide documentation that material was obtained from an NJDOT approved source and provide producer/supplier certification and current (less than 1 month) test results on representative samples that demonstrate conformance to specification requirements; or

b. test material in accordance with ASTM C136 for conformance to specification requirements. One test per 2,500 cubic yards of stockpiled or in-place source material or minimum of one test per source or for changes in material consistency, whichever is greater.

3.9 SURVEYS

Survey shall be performed by a professional surveyor registered in the State of New Jersey. Survey grid coordinates shall reference New Jersey State Plane Coordinate System, North American Datum (NAD) of 1983 and elevations shall reference North American Vertical Datum 1988 (NAVD 88). Survey plans shall be prepared at a scale of 1 inch equals 30 feet with a contour interval of 1 foot.

3.9.1 Topographic and Physical Features Survey

a. Physical features: Provide survey of existing North Landfarm features evidenced during regrading activities, passive gas vents, fencing and gate. Provide location, ground surface, and top and bottom of feature elevations as appropriate.

b. North Landfarm subgrade surface: Survey subgrade surface prior to placing geosynthetic components of coarse aggregate surfaced cap.

c. North Landfarm final grade surface: Survey final surface of coarse aggregate surfaced cap.

3.9.2 Check Surveys

Provide survey checks of cap system, including but not limited to, the surface to receive geosynthetic materials (i.e., Geocomposite Gas Venting Layer, GCL, 40 mil LLDPE Geomembrane, and Geocomposite Drainage Layer), protective layer (i.e., top of Common Fill/bottom of NJDOT Coarse Aggregate), and top of NJDOT Coarse Aggregate to demonstrate that the materials are acceptably placed in the work. Provide survey checks of each layer as the work progresses to verify indicated lines, grades and thicknesses. Check survey locations shall be fixed and established using a construction baseline with offsets (i.e., fixed grid). Cross sections shall be taken on lines 50 feet apart, measured along the construction baseline, with readings at 50-feet intervals, at grade breaks along the cross section lines, at critical locations, and as directed by Engineer. Other cross section spacing and reading intervals may be used if determined appropriate by Engineer. Following placement of each layer or type of material, check survey of each layer shall be approved by Engineer before proceeding with the next step of the work.

3.9.3 Layer Thickness Check

Provide layer thickness check of coarse aggregate surfaced cap system, including but not limited to, thickness of protective layer (i.e., Common Fill) and thickness of NJDOT Coarse Aggregate layer to demonstrate that the materials are placed to the indicated thicknesses. Provide layer thickness

check of layers at same time as Check Survey as the work progresses. Layer thickness check shall utilize the location control established under paragraph “Check Surveys”. Provide layer thickness check during initial placement of each layer or type of material, at locations of maximum proposed grade where consolidation settlement is anticipated to be at a maximum, and as directed by Engineer. Excavation for layer thickness check shall be by hand or using the air/vacuum extraction technique and shall be performed in the presence of Engineer. Layer thickness check of each layer shall be approved by Engineer before proceeding with the next step of the work.

-- End of Section--

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A116	(2011; R2016) Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric
ASTM A121	(2019) Standard Specification for Metallic-Coated Carbon Steel Barbed Wire
ASTM A153	(2016) Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A392	(2011; R 2017) Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric
ASTM A702	(2013; R2018) Standard Specification for Steel Fence Posts, Hot Wrought
ASTM A780	(2009; R 2015) Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings
ASTM A824	(2001; R2017) Standard Specification for Metallic-Coated Steel Marcelles Tension Wire for Use With Chain Link Fence
ASTM A90	(2013; R 2018) Standard Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM C94	(2018) Standard Specification for Ready-Mixed Concrete
ASTM F1043	(2018) Standard Specification for Strength and Protective Coatings on Steel Industrial Fence Framework
ASTM F1083	(2018) Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
ASTM F567	(2014a; R 2019) Standard Practice for Installation of Chain-Link Fence

ASTM F626	(2014; R2019) Standard Specification for Fence Fittings
ASTM F883	(2013) Standard Performance Specification for Padlocks
ASTM F900	(2011; R2017) Standard Specification for Industrial and Commercial Steel Swing Gates
	HESS EHS & SR (HESS)
HESS PCRD	(2013) Standard protocol titled “Pre-Clearing and Remediation Drilling”. November 21.

1.2 SUBMITTALS

Submit the following to Engineer for approval. Submittals with an “NJDEP” or “EPA” designation require submittal to the New Jersey Department of Environmental Protection or U.S. Environmental Protection Agency, respectively, and as indicated. Submit the following:

SD-02 Shop Drawings

Fence Assembly

Location of Gate, Corner, End, and Pull Posts

Gate Assembly

Gate Hardware and Accessories

Erection/Installation Drawings

SD-03 Product Data

Fence Assembly

Gate Assembly

Gate Hardware and Accessories

Barbed Wire

Zinc Coating

Fabric

Tension Bars

Concrete

SD-04 Samples

Fabric

Posts

Braces

Line Posts

Tension Wire

Gate Posts

Gate Hardware and Accessories

Padlocks

Wire Ties

SD-07 Certificates

Certificates of Compliance

SD-08 Manufacturer's Instructions

Fence Assembly

Gate Assembly

Hardware Assembly

Accessories

1.3 QUALITY CONTROL

Submit certificates of compliance in accordance with the applicable reference standards and descriptions of this section for the following:

a. Zinc coating

b. Fabric

c. Tension bars

d. Gate hardware and accessories

e. Concrete

1.4 DELIVERY, STORAGE, AND HANDLING

Deliver materials to site in an undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

Provide fencing materials conforming to the requirements of ASTM A116, ASTM A702, ASTM F626.

Submit reports of listing chain-link fencing and accessories regarding weight in ounces for zinc coating.

Submit manufacturer's catalog data for complete fence assembly, gate assembly, hardware assembly and accessories.

2.2 COMPONENTS

2.2.1 Fabric

ASTM A392; Class 2, zinc-coated steel, 9 gage. Mesh size, 2 inch diamond, with dimensions of fabric and wire conforming to ASTM A116, with minimum 2.0 ounces per square foot zinc galvanizing. Provide selvage knuckled at bottom and twisted and barbed at top. Width of fabric as indicated.

Provide one-piece fabric widths for fence heights up to 12 feet.

2.2.2 Line Posts

ASTM F1083, zinc coated. Group IA round steel pipe, with external coating Type A. Group IC round steel pipe, zinc coated with external coating Type A. Group II, roll-formed steel shapes (C-sections), meeting the strength and coating requirements of ASTM F1043 and ASTM A702. Group III, ASTM F1043 hot-rolled steel shapes (H-beams) may be used for line posts in lieu of line post shapes specified for the other classes.

2.2.3 Braces and Rails

ASTM F1083, zinc coated. Group IA round steel pipe. Group IC round steel pipe, zinc coated, meeting the strength and coating requirements of ASTM F1043 and ASTM A702. Group II, roll-formed steel shapes (C-sections), conforming to ASTM F1043, may be used as braces and rails if Group II line posts are furnished.

2.2.4 Tension Bars

Provide bars that have one-piece lengths equal to the full height of the fabric with a minimum cross section of 3/16 by 3/4 inch, in accordance with ASTM F626.

2.2.5 Tension Bar Bands

Provide bar bands for securing tension bars to posts that are steel, wrought iron, or malleable iron spaced not over 15 inches on center. Bands may also be used in conjunction with special fittings for securing rails to posts. Provide bands with projecting edges chamfered or eased.

2.2.6 Post Tops

Provide tops that are steel, wrought iron, or malleable iron designed as a weathertight closure cap. Provide one cap for each post, unless equal protection is provided by a combination post-cap and wire supporting arm.

2.2.7 Gate Posts

ASTM F1083, zinc coated.

2.2.8 Gates

ASTM F1083, zinc coated. As indicated.

For gate leaves over 6 feet high or 6 feet wide, provide perimeter gate frames of 1.90 inch O.D. pipe Grade A weighing 2.72 pounds per linear foot.

Provide gate frame assembly that is welded or assembled with special malleable or pressed-steel fittings and rivets to provide rigid connections. Install fabric with stretcher bars at vertical edges; stretcher bars may also be used at top and bottom edges. Attach stretcher bars and fabric to gate frames on all sides at intervals not exceeding 15 inches. Attach hardware with rivets or by other means which provides equal security against breakage or removal.

Provide diagonal cross-bracing, consisting of 3/8 inch diameter adjustable-length truss rods on welded gate frames, where necessary to obtain frame rigidity without sag or twist. Provide nonwelded gate frames with diagonal bracing.

2.2.9 Gate Hardware and Accessories

Provide gate hardware and accessories that conforms to ASTM A116 and ASTM F626, and be as specified:

Provide malleable iron hinges to suit gate size, non-lift-off type, offset to permit 180-degree opening.

Provide latch that permits operation from either side of the gate, with a padlock eye provided as an integral part of the latch.

Provide stops and holders of malleable iron for vehicular gates. Provide stops that automatically engage the gate and hold it in the open position until manually released.

Provide double gates with a cane bolt and ground-set keeper, with latch or locking device and padlock eye designed as an integral part.

2.2.10 Miscellaneous Hardware

ASTM A153, Table 1 hot-dip galvanized hardware.

2.2.11 Wire Ties

As indicated. Hog rings, 0.105-inch diameter.

2.2.12 Barbed Wire

ASTM A121 zinc-coated, Type Z, Class 3, with 12.5 gauge, round, 4-point barbs spaced no more than 5 inches apart.

2.2.13 Padlocks

ASTM F883, with chain.

2.3 MATERIALS

2.3.1 Zinc Coating

Provide hot-dip galvanized (after fabrication) ferrous-metal components and accessories, except as otherwise specified.

Provide zinc coating of weight not less than 1.94 ounces per square foot, as determined from the average result of two specimens, when tested in accordance with ASTM A90.

Provide galvanizing repair material that is cold-applied zinc-rich coating conforming to ASTM A780.

2.3.2 Tension Wire

ASTM A824, galvanized, coiled spring wire, No. 7-gage. Provide zinc coating that weighs not less than 2.0 ounces per square foot.

2.3.3 Concrete

ASTM C94, 3/4 inch maximum size aggregate, and minimum 28-day compressive strength of 3,000 psi.

PART 3 EXECUTION

Submit manufacturer's erection/installation drawings and instructions that detail proper assembly and materials in the design for fence, gate, hardware and accessories.

Provide complete installation conforming to ASTM F567.

3.1 PREPARATION

Ensure final grading and established elevations are complete prior to commencing fence installation.

3.1.1 Clearing and Grading

Establish a graded, compacted fence line prior to fencing installation.

3.2 INSTALLATION

3.2.1 Fence Installation

Install fence on prepared surfaces to line and grade indicated. Secure fastening and hinge hardware in place to fence framework by peening or welding. Allow for proper operation of components. Coat peened or welded areas with a repair coating matching original coating. Install fence in accordance with fence manufacturer's written installation instructions except as modified herein.

3.2.1.1 Post Spacing

Provide line posts spaced as indicated. Provide gate posts spaced as indicated. Provide corner or pull posts, with bracing in both directions, for changes in direction of 15 degrees or more, or for abrupt changes in

grade. Submit drawings showing location of gate, corner, end, and pull posts.

3.2.1.2 Top and Bottom Tension Wire

Install top and bottom tension wires before installing chain-link fabric, and pull wires taut.

3.2.2 Excavation

Provide excavations for concrete bases of minimum sizes as indicated in virgin or compacted soil. Excavate using hand-auger or soft dig methods in accordance with HESS PCRD. Place excavated material within North Landfarm limits beneath cap.

Space footings as indicated. Set posts plumb and in alignment. Set posts as indicated when in firm, undisturbed soil. Set posts deeper, as required and directed by the Engineer, in soft and problem soils and for heavy, lateral loads.

3.2.3 Setting Posts

Remove loose and foreign materials from holes and moisten the soil prior to placing concrete.

Provide tops of footings that are trowel finished and sloped or domed to shed water away from posts. Set hold-open devices, sleeves, and other accessories in concrete.

Keep exposed concrete moist for at least 7 calendar days after placement or cured with a membrane curing material, as approved.

Maintain vertical alignment of posts in concrete construction until concrete has set.

3.2.3.1 Bracing

Brace gate, corner, end, and pull posts to nearest post with a horizontal brace used as a compression member, placed at least 12 inches below top of fence; and a diagonal brace and truss rod as indicated.

a. Tolerances

Provide posts that are straight and plumb within a vertical tolerance of 1/4 inch after the fabric has been stretched. Provide fencing and gates that are true to line with no more than 1/2 inch deviation from the established centerline between line posts. Repair defects as directed.

3.2.4 Concrete Strength

Provide concrete that has attained at least 75 percent of its minimum 28-day compressive strength, but in no case sooner than 7 calendar days after placement, before rails, tension wire, or fabric are installed. Do not stretch fabric and wires or hang gates until the concrete has attained its full design strength.

3.2.5 Tension Wire Installation

Install tension wire by weaving them through the fabric and tying them to each post with not less than 7-gage galvanized wire or by securing the wire to the fabric with 10-gage ties or clips spaced 24 inches on center.

3.2.6 Fabric Installation

Provide fabric in single lengths between stretch bars with bottom knuckled selvage placed as indicated above the ground line. Pull fabric taut and tied to posts, rails, and tension wire with wire ties, hog rings and bands.

Ensure fabric remains under tension after the pulling force is released.

3.2.7 Fence Post Rigidity Testing

Test fence post rigidity by applying a 50 pound force on the post, perpendicular to the fabric, at 5 feet above ground. Post movement measured at the point where the force is applied shall be less than or equal to 3/4 inch from the relaxed position. Test every post for rigidity. When a post fails this test remove, replace, and retest.

3.2.8 Fabric Tautness Testing

Test fabric tautness by applying a 50 pound push-pull force at the center of the fabric between posts; the use of a 30 pound pull at the center of the panel shall cause fabric deflection of not more than 2.5 inches when pulling fabric from the post side of the fence. Fabric should return to its original position when force is removed. Test every panel for tautness. When a panel fails this test resecure and retest.

3.2.9 Gate Installation

Install gates plumb, level, and secure, with full opening without interference. Install ground set items in concrete for anchorage as recommended by the fence manufacturer. Adjust hardware for smooth operation and lubricated where necessary.

3.2.10 Tie Wires

Provide tie wires that are U-shaped to the pipe diameters to which attached. Twist ends of tie wires not less than two full turns and bent so as not to present a hazard.

3.2.11 Fasteners

Install nuts for tension bands and hardware on the side of the fence opposite the fabric side. Peen ends of bolts to prevent removal of nuts.

3.2.12 Zinc-Coating Repair

ASTM A780. Clean and repair galvanized surfaces damaged by welding or abrasion, and cut ends of fabric, or other cut sections with specified galvanizing repair material applied in strict conformance with the manufacturer's printed instructions.

3.2.13 Accessories Installation

3.2.13.1 Post Caps

Install post caps as recommended by the manufacturer.

3.2.13.2 Padlocks

Provide padlocks for gate openings and provide chains that are securely attached to gate or gate posts. Provide padlocks keyed alike, and provide two keys for each padlock.

3.3 CLOSEOUT ACTIVITIES

Remove waste fencing materials and other debris from the work site.

-- End of Section --

APPENDIX E

CONSTRUCTION COST ESTIMATE

COST ESTIMATE
SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION
FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

Item No.	Item Description	Units	Quantity	Unit Cost	Total Cost
Direct Capital Costs					
1.0	***Mobilization and Site Preparation***				
1.1	Mobilization/Demobilization	LS	1	$ 29,558	$ 29,558
1.2	Temporary Access Road	SY	140	$ 7	$ 980
1.3	Erosion and Sediment Controls	LS	1	$ 2,251	$ 2,251
	Silt Fence	LF	400	$ 3.35	$ 1,338
	Stabilized Construction Entrance	LS	1	$ 913	$ 913
1.4	Temporary Decontamination Pad	LS	1	$ 4,918	$ 4,918
1.5	Lysimeter Abandonment	LS	1	$ 4,000	$ 4,000
1.6	Demolition of Chain Link Fence & Gate	LS	1	$ 1,056	$ 1,056
1.7	Survey Control and As-Builts	LS	1	$ 5,000	$ 5,000
1.8	Standing Water Removal and Treatment	LS	1	$ -	$ -
1.9	Site Superintendence & Office Support	WK	8.5	$ 11,247	$ 95,601
2.0	***North Landfarm Cap System***				
2.1	Clearing and Grubbing	ACRE	0.4	$ 800	$ 300
2.2	Temporary Runoff Control	LS	1	$ 2,500	$ 2,500
2.3	Proof Roll Subgrade	BCY	680	$ 0.66	$ 449
2.4	Excavation of Subgrade Material	BCY	120	$ 4.08	$ 490
2.5	Import of Common Fill Material (Subgrade)	LCY	740	$ 34.25	$ 25,345
2.6	Backfill of Subgrade Material	LCY	150	$ 1.51	$ 227
2.7	Compaction of Subgrade/Common Fill Material	BCY	1,360	$ 0.84	$ 1,142
2.8	6" Thick NJDOT No. 2 or 3 Coarse Aggregate Surface Layer	LCY	330	$ 34.57	$ 11,409
2.9	6 oz/sy Separation Geotextile	SY	1,920	$ 4.55	$ 8,736
2.10	18" Common Fill Protection Layer	LCY	960	$ 34.25	$ 32,880
2.11	Geocomposite Drainage Layer (double-sided)	SY	1,920	$ 8.10	$ 15,552
2.12	40 mil Smooth or Textured LLDPE Geomembrane (unit price for textured shown)	SY	1,920	$ 9.27	$ 17,798
2.13	Geosynthetic Clay Liner	SY	1,920	$ 14.36	$ 27,571
2.14	Geocomposite Gas Venting Layer (single-sided)	SY	1,920	$ 7.47	$ 14,342
2.15	NJDOT No. 1 Coarse Aggregate Cap Termination Stone	LCY	30	$ 36.23	$ 1,087
2.16	Passive Gas Vents	EACH	2	$ 275	$ 550
2.17	Geomembrane Boot	EACH	2	$ 236	$ 472
3.0	***Site Security***				
3.1	Security Fence	LS	1	$ 21,296	$ 21,296
3.2	Signage	LS	4	$ 153	$ 612
				Subtotal Direct Capital Costs	$ 325,142
4.1			Scope Contingency	5%	$ 16,257
4.2			Bid Contingency	15%	$ 51,210
4.3			General Contingency	15%	$ 51,210
				Total Direct Capital Costs	$ 443,819
Indirect Capital Costs					
5.1	Construction Oversight & Completion Report			15%	$ 66,573
				Subtotal Indirect Capital Costs	$ 66,573
				Total	**$ 510,390**

See attached sheets for estimate notes and assumptions.

NOTES AND ASSUMPTIONS
SOIL REMEDIAL ACTION DESIGN
AOC-1: NORTH LANDFARM
HESS CORPORATION
FORMER PORT READING REFINING FACILITY
PORT READING, MIDDLESEX COUNTY, NEW JERSEY

Direct Capital Costs

1.0 Mobilization and Site Preparation

Item 1.1: Assumed 10% of direct capital costs. Percentage estimated from KEY's past experience.

Item 1.2: Assumed temporary access road 640 ft in length and 140 sy in area. Minimum 14 ft roadbed width for temporary one-way access road, minimum 20 ft roadbed width and minimum 30 ft length for turnouts. Cost of $7/SY obtained from contractor for construction of access road stone.

Item 1.3: Assumed 400 linear feet of silt fence required. Cost for silt fence obtained from RSMeans Line Item No. 312514161000, "Synthetic erosion control, silt fence, install and maintain, remove, 3' high" for a cost of $2.23/LF. Added 25% per month for maintenance, assuming 2 months.

Assumed stabilized construction access area of 800 sf. Cost of $7/SY obtained from contractor for construction of access road stone. Assumed $2.34/SY for geotextile obtained from RSMeans Line Item No. 334123190100, "Geotextile subsurface drainage filtration, fabric, laid in trench, polypropylene, ideal conditions." Marked up 10% to account for productivity decrease due to Level D safety requirements.

Item 1.4: Assumed decontamination pad area of 1000 sf (40 ft x 25 ft). Multiplied area by $9.34/SY using same material assumption found in Line Item 1.2. Assumed additional $0.38/sf for geomembrane material and $500 for timbers. Added $3,000 for Operation & Maintenance.

Item 1.5: Estimated from KEY's past experience.

Item 1.6: Cost for demolition of chain link fence posts and fabric obtained from RSMeans Line Item No. 024113601700, "Chain link, posts & fabric, 8'-10' high, remove only" for $4.63/LF. Cost for demolition of chain link gate obtained from RSMeans Line Item No. 024113620200, "Chain link, gates, 10'-12' width". Assumed salvage income of $300.

Item 1.7: Estimated from KEY's past experience assuming surveying crew and office labor to complete as-built drawings.

Item 1.8: To be provided by others.

Item 1.9: Estimated from KEY's past experience.

2.0 North Landfarm Cap System

Item 2.1: RSMeans Line Item No. 311313101040 "Selective tree and shrub removal, selective clearing brush mowing, medium density, tractor with rotary mower, excludes removal offsite." Area

calculated from construction drawings. Marked up 10% to account for productivity decrease due to Level D safety requirements.

Item 2.2: Estimated from KEY's past experience. Includes physical diversion and collection of stormwater. Storage and treatment costs included in Item 1.7.

Item 2.3: RSMeans Line Item No. 312323235100 "Compaction, riding, vibrating roller, 4 passes, 12" lifts" for a cost of $0.60/ECY. Area of 0.42 acres calculated from design drawings. Marked up 10% to account for productivity decrease due to Level D safety requirements.

Item 2.4: RSMeans Line Item No. 312316462020 "Excavating, bulk, dozer, open site, bank measure, common earth, 80 HP dozer, 50' haul" for a cost of $3.71/BCY. Quantity of 120 BCY estimated from cut volume obtained from design surfaces. Marked up 10% to account productivity decrease due to Level D safety requirements.

Item 2.5: Cost of $32.74/LCY for fill dirt obtained from Promatcher for Newark, NJ. Assumed 1 BCY = 1.25 LCY and added $1.51/LCY for dozer spreading per RSMeans Line No. 312323142020, "Backfill, structural, common earth, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction." Chemical analytical costs incidental to unit cost.

https://dirt-delivery.promatcher.com/cost/newark-nj-dirt-delivery-costs-prices.aspx

Item 2.6: RSMeans Line Item No. 312323142020 "Backfill, structural, common earth, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction" for a cost of $1.51/LCY. Accounts for backfill of cut material from Landfarm (i.e., not imported), assuming landfarm material is suitable for bedding/foundation layer. Chemical analytical costs incidental to unit cost.

Item 2.7: RSMeans Line Item No. 312323235040 "Compaction, riding, vibrating roller, 4 passes, 6" lifts" for a cost of $0.84/BCY. Quantity used accounts for subgrade compaction found in Item 2.5 and compaction of general fill material found in Item 2.10 and converted from LCY to BCY assuming 1.25 LCY = 1 BCY.

Item 2.8: Assumed 6" coarse aggregate material. Cost of $23.72/ton for aggregate obtained from Stavola Stone, delivered, including assumed 6.625% sales tax. Assumed delivered as LCY and 1 LCY = 1.4 tons as well as 1 BCY = 1.12 LCY. Added $1.36/LCY for dozer spreading per RSMeans Line No. 312323142000, "Backfill, structural, sand and gravel, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction." Subtracted quantity of stone required for cap termination.

Item 2.9: Cost of $0.95/SY for 6 oz/sy geotextile obtained from vendor. Assumed additional $0.40/SF ($3.60/SY) for installation. Area of 0.40 acres calculated from design drawings.

Item 2.10: Quantity of 1128 BCY obtained from cut/fill final surface volume to subgrade surface and subtracted quantity of cover stone and cap termination stone. Assumed cost of $32.74/LCY for fill dirt obtained from Promatcher for Newark, NJ. Assumed 1 BCY = 1.25 LCY and added

$1.51/LCY for dozer spreading per RSMeans Line No. 312323142020, "Backfill, structural, common earth, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction." Chemical analytical costs incidental to unit cost.

Item 2.11: Cost of $4.50/SY for double sided geonet obtained from vendor. Assumed additional $0.40/SF ($3.60/SY) for installation. Area of 0.40 acres calculated from construction drawings.

Item 2.12: Cost of $3.42/SY for 40 mil textured geomembrane obtained from vendor. Assumed additional $0.65/SF ($5.85/SY) for installation. Area of 0.40 acres calculated from design drawings.

Item 2.13: Cost of $8.51/SY for GCL, double sided geotextile obtained from vendor. Assumed additional $0.65/SF ($5.85/SY) for installation. Area of 0.40 acres calculated from design drawings.

Item 2.14: Cost of $3.87/SY for single sided geonet obtained from vendor. Assumed additional $0.40/SF ($3.60/SY) for installation. Area of 0.40 acres calculated from design drawings.

Item 2.15: Volume of termination stone required calculated from detail assuming wedge of 4 ft x 1.33 ft along southwest and southeast edge of cap totaling 250 ft. Assumed 6" coarse aggregate material. Cost of $24.91/ton for aggregate obtained from Stavola Stone, assuming 5% increase in cost in comparison to #2 aggregate to account for larger stone. Included 6.625% for sales tax. Assumed delivered as LCY and 1 LCY = 1.4 tons as well as 1 BCY = 1.12 LCY. Added $1.36/LCY for dozer spreading per RSMeans Line No. 312323142000, "Backfill, structural, sand and gravel, 80 HP dozer, 50' haul, from existing stockpile, excludes compaction."

Item 2.16: Estimated $100 for material costs from typical HDPE piping and assumed $150 for labor for perforations and assembly. Marked up 10% to account productivity decrease due to Level D safety requirements.

Item 2.17: Cost of $104.49 obtained from GEI Works, assuming geomembrane boot for 6” diameter pipe. Added 6% for sales tax, and added $25/ea. to account for shipping. Assumed $100 per geomembrane boot for installation.

3.0 Site Security

Item 3.1: RSMeans Line Item No. 323113200200 “Fence, chain link industrial, galvanized steel, 3 strands barb wire, 2” post @ 10’ OC, 9” ga. wire, 6’ high, schedule 40, includes excavation, & concrete” for a cost of $31.06/LF, assuming 5% increase in cost to account for 8’ high as compared to 6’ high. RSMeans Line Item No. 323113306675 “Fence, chain link, gates & posts, end posts, chain link fence, galvanized steel, (1/3 post length in ground), 3” OD, 7’, set

in concrete, includes excavation" for a cost of $118.68/ea. RSMeans Line Item No. 323113205080 "Fence, chain link industrial, double swing gates, 8' high, 12' opening, includes excavation, posts & hardware in concrete" for a cost of $1950.50/opening.

Item 3.2: RSMeans Line Item No. 101453200012 "Signs, stock, aluminum, reflectorized, 0.080" aluminum, 24" x 24", excludes posts" for a cost of $152.88. Assumed four signs will be installed.

4.0 Contingency

Item 4.1: Scope contingency represents project risks associated with an incomplete design that should become known as the design is completed. For specific remedial action technologies, a scope contingency of 10 to 20% should be used for synthetic caps. A 5% contingency was used in this estimate as this is a 90% design.

Item 4.2: Bid contingency added to account for unforeseeable costs at the time of cost estimate preparation. Bid contingency typically range from 10 to 20 percent. A bid contingency of 15% was used for North Landfarm.

Item 4.3: General contingency added to account for unforeseen site conditions that may be encountered during design implementation. A general contingency of 15% was used for North Landfarm.

Indirect Capital Costs

Item 5.1: Estimated as a percentage from KEY's past experience on similar projects. A construction oversight of 15% was used for North Landfarm.